Historic, archived document

Do not assume content reflects current scientific knowledge, policies, or practices.

A381
R31
Cop. 2

ARS 72–55
March 1967

Proceedings of the

CONFERENCE OF DIRECTORS AND COLLABORATORS

of

SOUTHERN AGRICULTURAL EXPERIMENT STATIONS

on

ADVANCES IN FOOD PROCESSING

Held at New Orleans, Louisiana
March 22 to 24, 1965

Agricultural Research Service
UNITED STATES DEPARTMENT OF AGRICULTURE

PREFACE

The Conference on Advances in Food Processing was held on March 22, 23, and 24, 1965, at the Jung Hotel in New Orleans, La. This conference was sponsored by the Southern Utilization Research and Development Division in cooperation with the Southern Agricultural Experiment Stations. Its purpose was to strengthen liaison between the SURDD and the Experiment Stations, and to exchange information on important subjects of joint interest.

In prior years attendance at the annual conference of these cooperating agencies has mostly been confined to their representatives. The topic this year, however, aroused interest throughout the country. Therefore the SURDD and the Southern Experiment Stations invited everyone interested in the area of food processing.

These proceedings report the statements presented by the various speakers during the conference and give an account of the discussions following.

Underscored numbers in parentheses refer to literature cited by the author. The references, figures, and tables are reproduced essentially as they were supplied by the writer of each paper.

Mention of companies or products used in this publication are solely for the purpose of providing specific information and does not imply recommendation or endorsement by the U. S. Department of Agriculture over others not mentioned.

CONTENTS

Page

OPENING SESSION

General Chairman, O. B. Garrison, Director
South Carolina Agricultural Experiment
Station, and Chairman, Southern Agricultural
Experiment Station Directors

Opening Remarks
O. B. Garrison 1

Welcome
C. H. Fisher 1

FIRST SESSION

D. Chambers, Louisiana Agricultural Experiment Station,
Chairman

Recent Developments in the Organization and Administration of Agricultural Research
N. C. Brady 2

Mold Toxins and Their Implications for Food
F. R. Senti 3

Status of the P. L. 480 Research Program
H. W. Marston 9

The Developing Nations and Their Special Needs for Processed Foods
M. Milner 12

Food Poisoning
G. M. Dack 15

Present Day Concepts of Fats in the Diet
G. A. Goldsmith 19

A Chemist's Look at the Future Sources of Food
A. T. McPherson 22

SECOND SESSION

Cochairman, L. G. MacDowell, Florida Citrus Commission, Lakeland, Florida, Presiding

H. H. Mottern, National Dairy Products Corporation, Chairman

New Foods from Spun Vegetable Protein
W. W. Thulin 28

Breeding Vegetables and Fruit for Processing
F. S. Jamison 35

Pure Culture Fermentation of Brined Cucumbers [Summary]
J. L. Etchells, R. N. Costilow, T. E. Anderson, and T. A. Bell. (Presented by
J. L. Etchells) 39

Page

Development of Peach Products
J. G. Woodroof, E. K. Heaton, T. S. Boggess, Jr., and K. C. Li (Presented by J. G. Woodroof) 39

Full-Fat Soy Flour
E. L. Griffin 44

THIRD SESSION

W. M. Roberts, North Carolina Experiment Station, Chairman

Some Economic Effects of Freeze-Drying
K. Bird 52

Foam-Mat Drying
A. I. Morgan, Jr., ... 58

New Rapid Freezing Techniques
H. K. Burr and M. S. Brown (Presented by H. K. Burr) 61

Quick-Cooking Dehydrated Fruits and Vegetables by Explosive Puffing
J. Cording, Jr., ... 65

Comparison of Food Dehydration Techniques
E. Seltzer 74

FOURTH SESSION

L. E. Hawkins, Oklahoma Agricultural Experiment Station, Chairman

High-Temperature-Short-Time (HTST) Sterilization of Foods and Aseptic Canning Methods
W. M. Martin 82

Outlook for Utilization of Southern Food Crops
J. C. Miller 85

Radiation Preservation of Foods
A. F. Novak 87

Hydrostatic Cookers
V. O. Wodicka 93

FIFTH SESSION

Panel Discussion - New Horizons in Food Processing
V. H. McFarlane, Southern Utilization Research and Development Division, Chairman 99

Raw Material Improvements
J. M. Lutz 100

The Future of Freeze-Dried Convenience Foods
T. J. McCaffery 102

Flavor Modification
E. T. Theimer 104

Quality Control
A. Kramer 108

What Consumers Want
H. G. Hamilton 111

Attendance List 124

OPENING REMARKS

by
O. B. Garrison, Director
South Carolina Agricultural Experiment Station

Gentlemen, I ask you to take your seats please. I call this session to order. I am O. B. Garrison, the general chairman of this Conference on Advances in Food Processing. I am ordinarily Director of the USDA Agricultural Experiment Station at Clemson, S. C., and I am also the present Chairman of the Southern Agricultural Experiment Station Directors.

I'd like to introduce as co-chairman, Dr. L. G. MacDowell, who is Director of Research of the Florida Citrus Commission at Lakeland, Fla.

The Department of Agriculture has had in progress in the United States for many years a program that revolves around regional research laboratories administered directly under the Department. One of those that has served the South very admirably has been this Southern Utilization Research and Development Division, with its associated laboratory located here in New Orleans.

We were fortunate in having assigned to this laboratory about 1950, Dr. C. H. Fisher, who had previous service at one of the other laboratories. He has done a very fine job at this laboratory, and I'd like to recognize him at this time to extend you a welcome. Dr. Fisher.

WELCOME

by
C. H. Fisher, Director
Southern Utilization Research
and Development Division

It is my great honor and pleasure to welcome this splendid audience and our distinguished guests and speakers to this important conference on food processing. It is pleasing to see so many. I hope that you will all find your stay in New Orleans very enjoyable and profitable.

We of the Southern Utilization Research and Development Division of USDA have the privilege each year of meeting with the collaborators representing each of the Southern State Experiment Stations. On a number of occasions, as is the case this year, the Directors of the State Experiment Stations and USDA Administrators honor and favor us by attending and participating in the Conference. This adds to the dignity and importance of the Conference, of course. We hope that the State Directors and USDA Administrators will participate in more of our future conferences--and that they will visit us more frequently.

I am grateful because I have had the privilege of working and meeting with Directors of the Southern Experiment Stations since 1950. I hope the participants of the Conference will have an opportunity of becoming better acquainted with the Directors and USDA Administrators while in New Orleans.

I have had the pleasure of attending several meetings of the State Directors in various states and in Puerto Rico and have enjoyed these meetings immensely. If the State representatives enjoy this Conference one-half as much as I have enjoyed the State meetings, they will indeed have a good time.

I must be brief, but I do wish to say a word about research in the USDA's Southern Division. About 60 percent of our total effort in the SURDD is invested in cotton utilization research. For this reason there is the tendency, at least in textile circles, to think of wash-wear cottons, stretch cottons, new cotton machinery, and the like, when the SURDD is mentioned. Nevertheless, the SURDD and its field Laboratories do a great deal of research concerned with the processing and utilization of food products. This research, done in cooperation with many organizations, has been highly profitable. I would like to mention a few examples to illustrate this point.

A giant among research achievements is frozen citrus concentrates. These came from cooperative work with the Florida Citrus Commission. It has been estimated that the citrus concentrate industry has paid about $500 million in Federal taxes since its beginning about 20 years ago. Because this is the 20th anniversary of the development of frozen concentrates, it would be appropriate to dedicate our Conference to this great research achievement and to the researchers responsible for it. The USDA presented its highest honor--the Distinguished Service Award-- to the group primarily responsible for this achievement. We are honored

because two important members of this group are here: L. G. MacDowell, Director of Research, Florida Citrus Commission, and M. K. Veldhuis, Director of USDA's Fruit and Vegetable Products Laboratory, Winter Haven, Florida.

Another major achievement resulted from cooperative research by the North Carolina Agricultural Experiment Station, the National Pickle Packers' Association, the pickle industry, and the USDA Food Fermentation Laboratory at Raleigh, N. C. The product, fresh pack pasteurized cucumbers, has an annual retail value of about $100 million. We are honored because the principal developer, and the leader of the USDA Food Fermentation Laboratory, is in the audience. He is Jack L. Etchells, who has done much valuable and money-making research during his fruitful career.

If we had sufficient time, I would be pleased to discuss other important achievements stemming from cooperative research involving the SURDD. Examples are:

Instant sweetpotato flakes, with important contributions from the Louisiana and North Carolina Agricultural Experiment Stations.

Processed pink grapefruit products from cooperative work by our Weslaco Laboratory, the Texas Agricultural Experiment Station, and the industry in the Rio Grande Valley. We are also honored to have Francis P. Griffiths, Director of the Weslaco Laboratory, in the audience today.

You will hear about acetoglycerides (cocoa butter-like fats) and other research achievements in food research at this Conference.

Many persons have contributed to this Conference, and I wish to thank all of them. First, I wish to congratulate and thank our Program Committee for doing a splendid job. Those on the Program Committee are: Bruno H. Wojcik, John J. Mikell, Vernon H. McFarlane, Harold J. Deobald, Henry L. E. Vix, and James J. Spadaro.

In addition, I wish also to thank our speakers and chairmen.

In closing, we at the Southern Utilization Research and Development Division invite the State Directors and their associates to meet with us again soon, either collectively or individually.

FIRST SESSION: D. Chambers, Louisiana Agricultural Experiment Station, Chairman

RECENT DEVELOPMENTS IN THE ORGANIZATION AND ADMINISTRATION OF AGRICULTURAL RESEARCH

by
N. C. Brady
Director of Science and Education
U. S. Department of Agriculture
Washington, D. C.

[The paper presented by Dr. Brady was essentially the same as his presentation before the Organization for Economic Cooperation and Development (OECD) Committee for Agriculture, Paris, France, October 14, 1964. This presentation has been published under the title "Organization and Administration of Agricultural Research in the United States." Copies are available on request from the Office of Science and Education.]

MOLD TOXINS AND THEIR IMPLICATIONS FOR FOOD

by
F. R. Senti
Agricultural Research Service
U. S. Department of Agriculture
Washington, D. C.

Introduction

Our interest today is focused on molds as toxin producers, potentially a most serious quality problem confronting the producers, manufacturers, and handlers of food and feed products.

At the outset, I should point out that molds are paradoxical: although many of us think of all molds as being harmful, nothing could be further from the truth. They are ubiquitous and abundant, but the vast majority of the 100,000 species cause no apparent harm to human beings or to animals. In fact, for centuries molds have been used in making prized foods such as Roquefort and Camembert cheese, and such staples of Oriental diet as miso, tempeh, and soya sauce. Ironically, even their toxicity depends on the point of view: to bacteria, penicillin is a lethal toxin; to man, it is a lifesaver. Useful products elaborated by molds are not limited to penicillin and the many antibiotics produced by the Streptomycetes group but include vitamins or their precursors, such as B_2, B_{12}, and beta-carotene, and a number of products used commercially, such as organic acids and commercial enzyme preparations.

The point to be made is that all molds do not produce toxins. It must be emphasized, however, that the molds used in the preparation of food are a selected few; the majority of the thousands of molds that occur in nature are undesirable in food or feeds because of their disagreeable odors and flavors. And a few do produce toxins.

Background of Mycotoxin Problem

Feeds

The problem of molds in feeds is not a new one, and it is not unique to any one industry. The list of reported deaths or ill effects resulting from consumption of moldy feeds is a long one. Animals poisoned include cattle, horses, pigs, sheep, and poultry. Materials implicated include various cereal grains, sweet clover, peanuts, cottonseed, and other agricultural products.

One of the first research workers to isolate the causative agent in naturally occurring mycotoxicosis among animals was Schofield, who identified two Aspergillus species in a sporadic outbreak of sweet clover poisoning among cattle in the early 1920's (18). About 30 years later, Aspergillus species isolated from feed were shown by Forgacs and coworkers to be implicated in bovine hyperkeratosis (5, 10). They soon also associated toxic fungi with the hemorrhagic syndrome in poultry (9). In 1957, Burnside, working with the Forgacs group, reported on a disease of swine and cattle that had eaten moldy corn. Although 13 molds were isolated from the corn, only two--Aspergillus flavus and Penicillium rubrum--gave products toxic to the animals (4).

Foods

That mycotoxicoses are reported more frequently among animals than among human beings is to be expected, since feedstuffs have undergone only a minimal amount of processing and since animals are fed the same ration for a long time (2). However, mycotoxins in foods have recently been recognized as hazards to human beings.

In several areas of Russia during World War II, the disease known as alimentary toxic aleukia was widespread and frequently lethal, especially in 1944 when food was so scarce that large portions of the population could subsist only by searching for grains that had been covered by snow all winter (14). Joffe reported the casual agents to be species of Fusarium (13); a freezing-thawing cycle especially favored their growth and, in the field, was requisite to their producing toxin (15). Toxicity was highest in samples of wheat, then millet, then barley; when moldy millet was examined after 6 or 7 years' storage, the toxin still persisted (14).

In the 1950's, discovery of toxic molds in rice imported by Japan threatened to

drastically curtail our large exports to them. The rice turned yellow, became bitter, and fortunately was not extensively consumed by human beings (16). However, when a regulated amount was fed to human beings as part of an investigation conducted by the Japanese Ministry of Public Health and Welfare, the subjects felt generalized weariness and gradually lost their appetite. Latent hypovitaminosis of B_1 and B_2 and disfunction of the liver were also evident (12). The causal fungus was identified as Penicillium islandicum, which produces at least two components that are hepatoxic and at least one that is carcinogenic in rats.

At the SURDD Japanese and American scientists examined tens of thousand of grains of rice produced in the South without finding a single one contaminated with P. islandicum. A comparable survey conducted by the WURDD showed that short-grained rice grown in California was essentially uncontaminated. On the basis of these findings, the Japanese government removed its restriction on the purchase of U. S. rice.

Current Mycotoxin Problem

Discovery in England

However, these isolated incidents did not attract much attention, even among specialists. Then 5 years ago the situation changed abruptly when thousands of young turkeys, ducklings, and other fowl died in England from a mysterious disease dubbed "turkey X disease." The common ingredient in their feed was rather quickly identified as an imported Brazilian peanut meal, and within about a year, the cause of the disease was discovered to be a toxic material produced by the very common mold, Aspergillus flavus. This toxic substance was christened aflatoxin after the name of the mold.

It was soon found that under favorable growth conditions A. flavus produces at least four toxins, which are similar but distinct chemical substances. They have been designated B_1, B_2, G_1, and G_2, the letters indicating which fluoresce blue and which green under ultraviolet light, and the subscripts identifying their relative mobility under specific conditions of chromatography. Only very small amounts of the four aflatoxins are found in plant products, amounts that are generally reckoned in parts per billion. But that is enough. They are extremely potent toxins, so potent that an ounce of aflatoxin B_1, properly distributed, could kill a million ducklings.

Background of U. S. Involvement

Before and even after the cause of "turkey X disease" was identified as a toxin produced by A. flavus, there was little concern in this country because it was thought that the contamination in foreign peanut meals was due to poor technology. In the spring of 1963, however, this situation changed. In April, a research group in California reported that a feed containing cottonseed meal had produced a high incidence of hepatoma in hatchery trout (22). As a consequence, the California State Department of Health eliminated cottonseed as an ingredient of dry feed used in California hatcheries. We now know that trout are extremely susceptible to aflatoxin, perhaps the most susceptible animal species; therefore, although the meal used in the California experiments was never analyzed for aflatoxin, it at least appears likely that aflatoxin was the causative agent of the observed hepatomas.

At almost the same time, in the spring of 1963, Professor Salmon of Auburn University reported that a diet containing domestic peanut meal had produced a high incidence of hepatoma in rats (17). Again, the presence of aflatoxin was a distinct possibility. Although peanut meal is not ordinarily produced from edible grades of peanuts, the Department of Agriculture, as well as the peanut industry, became concerned about the possible occurrence of molds in domestic peanuts.

Survey of CCC Peanut Stocks

Although the Department's first experimental work in this program involved cottonseed, we considered aflatoxin in peanuts to be the more immediately critical problem. A major phase of the Department's first work on peanuts was a survey of the incidence of aflatoxin in peanut stocks held by the CCC throughout the country, something like 200,000 tons of peanuts. This survey was an important factor in developing the Department's contract program for the marketing of the 1964 peanut crop. That program was designed to assure that only high quality peanuts are marketed for food and that those not meeting these standards are channeled into nonfood uses. A four-

phase program for peanuts was announced in July 1964: (a) changes in the price support program; (b) educational assistance to the peanut industry to help improve the quality of peanuts through improved methods of growing, harvesting, drying, storing, shelling, and processing; (c) Federal-State inspection of all lots of shelled peanuts; and (d) a research program seeking better ways to eliminate damage to peanuts, particularly damage due to molds. An important feature of this new price support program is an insurance provision designed to eliminate or to minimize losses from mold-damaged peanuts to peanut producers, shellers, or processors. The program is working out very well. The National Peanut Council adopted a Voluntary Code of Good Practices for purchasing, handling, storing, and processing peanuts.

In addition to providing information needed to develop the marketing program for the 1964 peanut crop, the survey also indicated the extent of the mold problem. There are aflatoxin-producing strains of Aspergillus flavus in all the important peanut-growing areas of the United States. None is free; all areas are involved. I should hasten to add that relatively few samples of No. 1 peanuts had any detectable amounts of aflatoxin and those that did had relatively low levels. Contamination generally occurs in damaged peanuts that are included in the pickouts removed in the grading process. Contamination also appears to be highly selective. That is, a few kernels carry relatively large amounts of aflatoxin and the vast majority contain no detectable amounts. Broad geographic involvement, similar to that observed within the United States, was also noted at the UNICEF meeting on Groundnut Toxicity Problems held in London in 1963. It was reported there that tests for aflatoxin had been carried out on groundnut samples from most of the groundnut-producing countries of the world. By no means did all samples contain toxin, but in no case was a country found to be free of the problem (3).

Nor is the problem necessarily limited to peanuts. Aspergillus flavus molds are widely distributed, and toxin-producing strains could occur in any of our grains and oilseeds. To complicate things a little more, it should be noted that the mold A. flavus produces toxic materials other than aflatoxin (21), and that aflatoxin is produced by molds other than A. flavus.

Initiation of Expanded Research Program by USDA

Accordingly, a broad research program involving a number of commodities was developed by the Department with the advice and cooperation of the experiment stations and of representatives from industry. The commodities now being investigated are peanuts, cottonseed, cereal grains, and soybeans. An increased appropriation for the current fiscal year has greatly aided in getting this program underway, and the research effort now amounts to more than a million dollars a year.

Although there is no direct evidence that aflatoxin is harmful to human beings, the problem has obvious significance in foods as well as feeds. We must recognize the possibility not only of their occurrence in foods themselves but also of their transmission into animal products such as milk, meat, and eggs. An experiment has been reported in which a toxic material appears to have been secreted in the milk of cows fed toxic peanut meal that contained very high levels of aflatoxin. The toxin was detected in the milk 12 to 24 hours after feeding of the contaminated peanut meal was begun and disappeared from the milk within four days after it was discontinued. The amount of toxin found in the milk was only about 1 percent of that in the feed (6). In another preliminary experiment, aflatoxin was not found in the liver from a cow and a pig or in eggs from pullets after the animals were fed rations containing toxic groundnut meal (1). Although animals may prove to be efficient "filters" of the toxin, the possibility of transmission needs extensive investigation.

Also focusing attention on the problem is the fact that developing countries are increasing their use of cottonseed flour as human food, a potential solution to the high incidence of diseases caused by protein deficiency. It is therefore necessary to assure the wholesomeness of the basic product and to develop specifications of quality for specific uses (11).

In this context--implications for foods and feedstuffs--the Department outlined the objectives of its research program to find practicable methods for preventing or at least minimizing mold growth:

(1) For guidance of research as well as for surveillance of commodities in marketing channels, rapid analytical methods for aflatoxin are needed, recognizing that each commodity may present special problems of analysis.

(2) To design effective measures for prevention, we must determine at which stage or stages in the growth, harvesting, handling, or storing of a commodity mold growth and contamination by toxin producers may occur.

(3) Finally, processes for removing or destroying toxins should be developed so that contaminated agricultural products need not be diverted to low value uses such as fertilizer.

Seven research divisions [1/] of the Agricultural Research Service and eight State agricultural experiment stations, [2/] many of them represented here today, are now involved in this program. To coordinate the ARS program and make it as effective as possible, a working group of Division representatives has been established with the Associate Administrator of the Agricultural Research Service as Chairman. Close liaison is maintained with the Agricultural Stabilization and Conservation Service of the Department and with the Food and Drug Administration of the Department of Health, Education and Welfare, two agencies that are also concerned with the aflatoxin problem.

Investigations by the Farm Research Divisions of ARS, in cooperation with the agricultural experiment stations, are important since the greatest opportunity for peanuts to become contaminated with mold appears to be on the farm. In fact, much of the Department's research program on molds in peanuts is directed toward developing methods and equipment that will eliminate or reduce contamination during digging, curing, and harvesting.

In addition to other work on peanuts, including long-range attempts to breed mold-resistant strains, Farm Research and the experiment stations are investigating fungi associated with soybeans and cottonseed in various stages of growth, particularly with respect to possible toxin-producing species.

The Marketing Research Divisions of ARS are studying the effects of storage treatments and other off-farm handling on the production of aflatoxin; developing methods for rapid detection of molds and fungal metabolites; and are developing improvements in storing, cleaning, shelling, and grading of peanuts. Some facets of their work also apply to rice and to cottonseed, particularly when boll rot is prevalent.

Three of the Utilization Research and Development Divisions--Southern, Northern, and Western--are also conducting extensive research programs on the aflatoxin problem. Most of the research thus far has been on peanuts and cottonseed, which I shall discuss first, but some of the findings may also be applicable to other products.

Methods developed by the SURDD for the analysis of peanut and cottonseed products are faster, more accurate, and more sensitive than those available only a year ago. A working standard of a solution containing known amounts of all four recognized aflatoxins has been prepared and is now available. Its use should improve the standardization of results between laboratories requesting it. For use as standard reference compounds and in feeding experiments for study of these chemical properties, and for many other applications, it is essential that aflatoxins be prepared in large quantities; fermentation research at the NURDD is being directed toward that goal. Another phase of the work on analytical methodology has been the development of micro or semimicro methods that permit assay of a single peanut kernel or even a small part of a kernel for aflatoxin.

The SURDD and WURDD and the experiment stations are cooperating in feeding tests on various experimental animals. For tests on trout, 200-pound batches of five cottonseed meals selected by the National Cottonseed

1/ Crops: Agricultural Engineering; Market Quality; Transportation and Facilities; and the Southern, Northern, and Western Utilization Research and Development Divisions.

2/ Virginia, Georgia, Oklahoma, Texas, Iowa, North Carolina, Alabama, and California.

Processors Association were extracted with special solvent mixtures and the extracts fed to the fish. At the recent conference of the Western Experiment Station Collaborators at our Western Division, Professor Sinnhuber of Oregon State University reported results on similar experiments (20).

Peanut meals are also being used in feed tests. Experiments in progress with rats will not only assay the effects of aflatoxin but are also designed to test the hypothesis that peanuts per se do not produce hepatomas. Tests now being conducted with swine are designed to show whether aflatoxin damages tissues and organs and whether it can be stored there and thus be transmitted in meat.

Several procedures for removing or inactivating aflatoxin in cottonseed products on which toxin producing strains of A. flavus have been grown appear promising. The acetone-hexane-water mixed solvent developed to remove gossypol also removes aflatoxin from cottonseed during processing. The aflatoxin goes into the oil, just as the gossypol does, but it is removed during refining and bleaching of the oil. This mixed solvent can also remove aflatoxin from finished cottonseed and peanut meal without excess loss of other material. Other low-cost solvent mixtures have also been found to be effective. The effect of various chemical treatments to inactivate aflatoxin is now being studied, and some of them--for example, treatment with ammonia--appear potentially useful. The Food and Drug Administration, which is also studying detoxification of aflatoxin, recently reported that when peanut meal containing about 1,000 ppb of aflatoxin, was exposed overnight to a 10 percent chlorine gas atmosphere, it lost its toxicity as judged by bioassay with the chick embryo (7). Although we are not yet prepared to recommend any of these processes, hopefully it will not be too long before we can.

With the cooperation of the Experiment Stations, commodities other than peanuts and cottonseed are also being studied. Samples of soybeans selected during the growing season, after farm storage, and from feed trade channels will be examined for toxin-producing molds. Rice from both food and feed channels is being examined. The Northern Laboratory is analyzing samples of wheat, corn, sorghum, oats, and soybeans collected by the Agricultural Marketing Service from carloads of grain received at the principal markets. Surveys such as these are necessary to determine whether a problem exists in these commodities and, if so, the extent of the problem.

From our knowledge of the properties of aflatoxin--that it is very stable to heat and moderately stable to most common chemicals--the present indications are that aflatoxin will not be completely removed or inactivated during most conventional food processing operations should it occur in the commodity being processed. What can we do then to safeguard our products? Fortunately, mold damaged products are now largely eliminated prior to processing for food because of the generally evident undesirable flavor and odors imparted by mold growth. However, the potential hazard emphasizes that commodities for processing should be selected with great care to eliminate all mold damage even though most molds do not produce aflatoxin. Probably the best way to minimize the problem is through measures taken in growing, harvesting, and storage to prevent mold growth (19).

The most important environmental factors in growth of mold and production of aflatoxin are temperature and moisture. The optimum temperature for mold growth varies with the type of mold. For example, when corn was stored at a relative humidity of 80 percent, a species of Penicillium was predominate at 25°C., A. flavus at 30°C., A. glaucus at 35°C., and a species of Mucor at 45°C. (8). The optimum humidity requirement for mold growth also varies with the type of mold. The conditions that promote growth of A. flavus and production of toxins appear to be relatively high temperature and high humidity. The optimum temperature for the production of aflatoxin appears to be different for different strains of A. flavus but seems to lie in the range of about 75° to 95°F.; relatively little growth of A. flavus and production of aflatoxin occur at temperatures below about 65°F.

Moisture content is extremely important and will perhaps be the easiest to control. In the case of peanuts it appears that molds grow very slowly, if at all, when the moisture content is below 9 percent. It should be emphasized, however, that this is the moisture content of the individual kernel and not the average moisture content. Uneven moisture distribution among kernels may result in mold growth even when the average moisture

content is apparently at a safe level. Since the mold produces moisture as it grows, once fungal growth has started in one wet kernel further fungal proliferation may proceed regardless of the average moisture content.

In the case of cottonseed the safe level of moisture content is somewhat higher, probably in the region of about 11 percent. Actually the safe moisture content is dependent upon the temperature. If the temperature is low, more moisture can be allowed; if the moisture is low, a slightly higher temperature can be allowed. However, good practice would dictate that the moisture content be reduced to below about 11 percent and the temperature be below 60° or 65° F. as rapidly as feasible.

In research on toxic factors in feedstuffs or in foods, a major concern must be not only the acute but also the subtle long-term effects. The acute effects of aflatoxin thrust the problem upon us, but investigation of the long-term effects is just beginning. Perhaps the results of these intensive efforts will suggest a means of anticipating, detecting, and avoiding potential problems of food safety before they break upon us in the future.

References

(1) Allcroft, R., and Carnaghan, R. B. A., Vet. Rec. 75, 259-263 (1963).

(2) Anon. Nutr. Rev. 20, 339-342 (1962).

(3) Bampton, S. In Summary of Proceedings of UNICEF Meeting on Groundnut Toxicity Problems, 50 pp. processed (1963).

*(4) Burnside, J. E., Sippel, J. E., Forgacs, J., Carll, W. T., Atwood, M. B., and Doll, E. R., Amer. J. Vet. Res. 18, 817-824 (1957).

*(5) Carll, W. T., Forgacs, J., and Herring, A. S., Amer. J. Hyg. 60, 8-14 (1954).

(6) de Iongh, H., Vies, P. O., and Van Pelt, J. G., Nature 202, 466-467 (1964).

(7) Fischback, H. and Campbell, A. D., J. A. O. A. C. 48, 28 (1965).

(8) Forgacs, J. In Maryland Nutr. Conf. for Feed Mfrs. Proc. (1962).

*(9) Forgacs, J. and Carll, W. T., Vet. Med. 50, 172 (1955)

*(10) Forgacs, J., Carll, W. T., Herring, A. S., and Mahlandt, B. G., Amer. J. Hyg. 60, 15-26 (1954).

(11) Friedman, L., Food Technology 18, 1553-1563 (1964).

(12) Inoue. In Abstracts of the Tests of the Toxicity of the Deteriorated Rice, Ministry of Public Health and Welfare, Japan (1954) 22 pp. processed.

(13) Joffe, A. Z., Mycopathologia Mycologia Appl. 16, 201-207 (1962). (microfilm)

(14) Joffe, A. Z., Plant and Soil 18, 31-44 (1963).

(15) Mayer, C. F., Mil. Surg. 113, 173-189 and 295-315 (1953).

(16) Miller, J. A., Natl. Acad. Sci.--Natl. Res. Council, Food and Nut. Board, Proc. 22, 5033 (1962).

(17) Salmon, W. D. and Newberne, P. M., Cancer Res. 23, 571-575 (1963).

*(18) Schofield, F. W., J. Amer. Vet. Med. Assn. 64, 553-575 (1924).

(19) Shimkin, M. B. and Kraybill, H. F., Amer. Med. Assoc. J. 185, 737 (1963).

(20) Sinnhuber, R. O. In program and Abstracts of Papers, Western Experiment Station Collaborators Conference, 14 pp. processed (1965).

(21) Wilson, B. J. and Wilson, C. H., Science 144, 177-178 (1964).

(22) Wolf, H. and Jackson, E. W., Science 142, 676-678 (1963).

* Original source not consulted; referred to by Forgacs, J. Feedstuffs 34, 124-134 (1962).

STATUS OF THE P. L. 480 RESEARCH PROGRAM

by
H. W. Marston
Foreign Research and Technical Programs Division
Agricultural Research Service
U. S. Department of Agriculture
Washington, D. C.

Authority for the U. S. Department of Agriculture's foreign research program is contained in the Agricultural Trade Development and Assistance Act of 1954, more commonly known as Public Law 480. The preamble of the Act "declared it to be the policy of Congress to expand international trade among the United States and friendly nations, ...to make maximum efficient use of surplus agricultural commodities in furtherance of the foreign policy of the United States, and to stimulate and facilitate the expansion of foreign trade in agricultural commodities produced in the United States by providing a means whereby surplus agricultural commodities in excess of the usual marketings of such commodities may be sold through private trade channels, and foreign currencies accepted in payment therefor."

Title I--Section 104, subsections (a) and (k) of the Law provide the authorization under which the USDA operates. These are just 2 of the 19 subsections authorizing various uses for these foreign currencies accumulated to the credit of the United States.

Section 104(a) authorizes work "to help develop new markets for United States agricultural commodities on a mutually benefiting basis." This authority has been interpreted to include research on the development of new and extended uses for farm products, and marketing and nutrition research. This section provides for "the convertibility of such amount of the proceeds (of sales) as the Secretary of Agriculture determines to be needed to carry out the purposes of this subsection in those countries which are, or offer reasonable potential of becoming, dollar markets for United States agricultural commodities."

Section 104(k) is much broader in its authority. This subsection authorizes the following: "to collect, collate, translate, abstract, and disseminate scientific and technological information and to conduct research and support scientific activities overseas including programs and projects of scientific cooperation between the United States and other countries such as coordinated research against diseases common to all mankind or unique to individual regions of the globe, and to promote and support programs of medical and scientific research, cultural and educational development, health, nutrition, and sanitation." Not only the Department of Agriculture but also the Departments of Health, Education and Welfare, Commerce, and Interior have initiated research programs abroad under this subsection. All of the programs under this section are now restricted to those countries in which the United States has foreign currency in excess of its normal and anticipated needs. The so-called excess currency countries at this time are: Israel, Egypt, Poland, Yugoslavia, India, Pakistan, and Burma. At one time funds were provided to support research under Section 104(k) in a number of nonexcess currency countries in Asia, Europe, and South America.

The first grants executed under the USDA program were signed late in fiscal year 1958. Beginning in the fall of the fiscal year 1959, teams of research people visited a number of countries in Europe and Asia to explore the research potentials of the countries. Later a similar team visited South America. Our program was explained to and cleared with the American Embassy in each country and with the proper authorities of the Government of that country, usually the Ministry of Agriculture. These teams also solicited, at research institutions in each country visited, the preparation of research proposals of mutual interest to the agriculture of the country and to U. S. agriculture.

When research proposals are received they are referred to the proper subject matter agency within the Department. The subject matter specialists are instructed to review each proposal with the following criteria in mind: (1) Will the expected results of the research be of value to American agriculture; (2) does the work complement or

supplement existing research; (3) is the plan of work adequate to accomplish the objectives of the research; and (4) are the estimated costs of doing the research reasonable. The agency makes one of several choices: (1) It approves the proposal as received; (2) suggests modifications or revisions to make it acceptable; (3) suggests a counterproposal; or (4) rejects the proposal as being unsuitable.

The Department has received, as of December 31, 1964, a total of 2,362 research proposals that have been reviewed by appropriate agencies in the Department.

When the Washington office receives the agency comments, the institution making the proposal is notified of the action. If the proposal is accepted, arrangements are made to negotiate the grant at the proposing institution. Negotiation involves a final review of the institution and its facilities; an evaluation of the apparent capabilities of the person who is to be the principal investigator; and any last-minute changes in the project plans that are deemed necessary. Negotiation also involves a final agreement on the costs of doing the research. Reports of each negotiation are prepared by the technical and fiscal negotiators and forwarded to Washington for a final review. When approved by the proper research agency, a grant letter is issued to the institution doing the research and the grant becomes effective upon the date when the grantee institution signs the grant letter.

Grants have been executed in 29 countries in Europe, Asia, and South America. In order to handle the details of negotiations and to administratively supervise the operation of grants, a European Regional Office was established in Rome, Italy, where Mr. W. F. Talburt is the Director, and a Far Eastern Regional Office in New Delhi, India, where A. D. Ayers is the Director. Administration of grants in South America is done by the Washington office.

When a signed grant letter is received in either Rome, New Delhi, or Washington, steps are taken at once to authorize the Disbursing Officer in the American Embassy in the country concerned to make the first payment to the grantee institution. The first payment includes the recurring expenses for a period of about eight months, plus the agreed upon costs of nonrecurring items. At the end of six months we require both a technical and fiscal report from the grantee. The fiscal report includes an estimate of operational costs for the next six months. When these reports are approved, another payment is authorized.

The life of a grant can be no more than five years. In addition to the reports mentioned above, the grantee institution agrees to furnish copies of any reprints or publications; to prepare a final report and a final accounting of funds. One additional item required is assistance in preparing information for a U. S. patent on any patentable ideas developed.

Since the foreign agricultural research program was initiated there have been a total of 623 grants approved. Of these, 63 have been terminated and, as of December 31, 1964, there were 560 active grants. The grants cover the following subject matters: 250 are in the area of responsibility of Farm Research; 167 in Utilization Research and Development; 82 in Forest Research; 34 in Market Quality; 14 in Human Nutrition; and 13 in Economic Research.

Since this conference is concerned with advances in food processing, it should be pointed out that the P. L. 480 research program under the sponsorship of Utilization Research and Development has been active in this area. Much of the research in this field is concerned with the basic chemistry of the constituents of various food products; the effect of processing treatments on these constituents; and to provide further information on how new knowledge can best be used to develop new or improved food products. The commodities toward which this aspect of the program is directed are fruits and vegetables, milk, meat, soybeans, eggs, and cheese.

Other examples of research in the area of utilization are: Investigations of the setting reactions for cotton fabrics and garments (Sweden); isolation, characterization, and quantitative determination of the sterols in soybeans (Japan); investigation of the chemical changes occurring at the surface of the fat globules in stored foam-dried milk (West Germany); study of the antioxidant components of wood smoke used in meat curing, and the effects of methods of generation on the quantity and activity of the antioxidant components of the smoke (Poland); measurement of viscoelastic properties of wheat flour

doughs (Australia); preparation, characterization, and evaluation of derivatives of gossypol from cottonseed for use as biologically active materials (Uruguay).

Examples of research in the area of Market Quality are: Studies on residues of insecticides and fungicides applied to different plant products after harvest, the stability of the residues during marketing, storage, food preparation and preservation, and the effects of pesticides on food quality (Finland); studies on the constituents of rice influencing quality, and development of objective methods for measuring market quality of raw and precooked rice (Spain); isolation and structure of germination inhibitors in seeds (Israel); developing an instrument for homogenizing and orienting fibers in samples for cotton testing (France).

The majority of the research grants supported with 104(k) funds are in farm and forestry research. Much of this research is in areas that offer environmental conditions that cannot be easily duplicated in the United States. For example, special attention has been given to discovering and evaluating parasites, predators, or pathogens of destructive insects present in the United States. Similar studies are underway on noxious weeds present in the United States. A few projects deal with animal diseases and parasites not now present in the United States but which could be introduced accidentally. Studies are also made of some plant diseases in their native habitat. There are a number of projects designed to find new plant materials that might profitably be introduced into the United States or could serve as sources of new germ plasm for improving presently grown crops of the United States. Other areas covered by the 104(k) program are in a miscellaneous group dealing with the physiology and nutrition of plants and animals, agricultural engineering, soil and water research, agricultural economics, etc.

Specific examples of research in the area of Farm Research are: Finding strains of oats resistant to oat-stem rust (Colombia); inducing sterility in males of the Mediterranean fruit fly as a means of controlling this pest (Egypt); parasites and predators of sugarcane borer (India); developing a rapid and accurate diagnostic test for African swine fever (Spain); and the relationship of the secretion of anterior pituitary hormones to ovulation in small ruminants (Poland).

Forestry Research work is underway on disease and insect susceptibility and species adaptability of some North American pine species (Brazil); the role of photoperiod in the rooting and growth induction of short shoots of pine (Chile); and the role of mycorrhizae in tree nutrition and growth (Finland).

Following are just a few examples of the results obtained to date:

In the area of biological control the United States has received numerous shipments of parasites of sugarcane borers, of balsam wooly aphids, of gypsy moths, and even of fire ants. These are being tested for adaptability and effectiveness against the insects they were imported to control.

The work in Spain on the diagnostic test for African swine fever is most promising. While presently not 100 percent effective, it is well on its way to being completely successful.

Two grants in England on scrapie disease of sheep are making outstanding progress. For the first time, the virus causing the disease has been transferred to mice. This should make it possible to speed up the progress on this, one of the most difficult diseases of animals.

Another grant in England has isolated an antioxidant of oats which has been characterized and offers a real potential for use as a natural antioxidant.

Since the beginning of the program approximately 50 million dollars equivalent has been made available for the P. L. 480 research program abroad. As an indication of research progress under these grants, we have received copies of more than 400 published articles, most of them in English. The program has had other beneficial effects that cannot be evaluated in dollars. It has been a most interesting program.

THE DEVELOPING NATIONS AND THEIR SPECIAL NEEDS FOR PROCESSED FOODS

by
M. Milner
United Nations Children's Fund (UNICEF)
United Nations, New York

As a representative of UNICEF, the U. N. agency which has the responsibility for assisting governments of developing countries to improve the health and general welfare of infants and children, including their nutritional status, I am delighted that our friends at the Southern Regional Research Laboratory have provided this opportunity for me to speak to you on the special needs for processed foods in developing countries. First may I tell you that in the area of food technology relating to such needs, a highly productive and I believe mutually advantageous collaboration has developed during the past six years between UNICEF and various laboratories of the Agricultural Research Service. UNICEF welcomes this opportunity to inform you of some useful consequences which have come about from this collaboration, and we would hope that from this meeting there will develop analogous contacts between the United Nations agencies and the scientists and technologists of the U. S. Land Grant institutions.

The sobering implications of rapid world population growth to food requirements, particularly in developing countries whose conventional food production is already strained, needs no emphasis in this group. It is clear that traditional agriculture as practised in many of these countries is not only failing to meet rapidly increasing food needs, but also the potential for growth of these agricultures may have been overestimated. To meet immediately foreseeable needs these agricultures must be upgraded at previously unattained rates. There must also be achieved in the reasonable future some measure of stabilization of population growth.

There is a growing belief also, that even optimum agricultural productivity and efficiency may be unable alone to solve the food problem, and that new, nonagricultural approaches to food production, based on as yet untested technology, will need to be called upon. It is in this special area that I wish to confine my comments today. I am pleased to see that other participants in this program including Dr. McPherson, Mr. Thulin, and Mr. Griffin will also address themselves to other aspects of food production or processing by nonagricultural methods.

A qualitative study of the world's food needs indicates to many authorities that the most urgent problem, beyond that of total dietary calories, is the shortage of protein. It is also clear that the total calorific value of available food per capita on a world basis has increased to some extent since World War II at a rate slightly exceeding that of population growth, although very recently this trend has been reversed. We may even expect in the short-term future that food surpluses such as sugar and wheat may actually increase. The fact remains, nevertheless, that the most serious single dietary deficiency is that of protein and this deficiency is increasing. A corollary point is that a country whose agriculture is already strained to its limits in the production of cereals or even of other staples such as starchy roots and fruits, can never hope to solve its protein needs via the animal route, when human and livestock must compete for the same limited food supply.

That protein scarcity will seriously retard the growth of economic, public health, and social welfare in countries where it is severe, is evident when it is recalled that it is the root cause for the high death rates and probably also the impaired physical and mental development of infants and young children in countries where ideal weaning foods such as milk are virtually unavailable. I suspect that to some of you the image of UNICEF is that of a "milk" organization and it is indeed true that in the past 18 years the bulk of our resources and energies on the nutrition side have been devoted to distribution of dry milk to meet emergency situations, and also to assist countries establish modern milk processing plants to provide such products for the needs of children of lower income urban families in more than 30 countries. Nevertheless, our "moment of truth" is already upon us since several countries where milk conservation programs assisted by UNICEF and other agencies have

been going forward, the economic limits of milk processing are being reached in terms of low-cost raw milk supplies. Several countries, particularly those in intensely tropical environments, may never develop milk production to the point where investment in pasteurizing and bottling plants for urban distribution will be feasible. Yet at precisely this moment the need for dietary protein to meet the critical needs of weanlings and toddlers has become more urgent than ever.

It is for these reasons that one of the major nonconventional areas of food resources being explored in developing countries is the processing and upgrading into human food of available protein materials that have heretofore been used largely for fertilizer purposes, or at best for animal feeding. In the limited time available to me today may I cite just one example of this new challenge.

India is the world's largest producer of peanuts--some 5 million tons annually. This crop is the mainstay of the national edible oil supply such as it is. Crushing of oilseeds is done by obsolescent technology with the consequence that not only is a significant part of the oil available in the nuts not recovered for food, but at the same time the incompletely deoiled byproduct presscake is of very low quality. Perhaps as much as 20 percent of this material may be fed to livestock or exported for hard currency, but by far the major part, residual oil and all, is used as manure. Thus, as much as 2-1/2 million tons of a potentially valuable protein (not to mention nutritious vegetable oil) is lost as food to an underfed, protein-deficient population--and a largely vegetarian population at that. A simple nutritional calculation indicates that if only 5 percent of a sanitary edible peanut flour were added to Indian atta (wheat flour), the diet of low income chepathi-eating peoples could be increased by at least 20 percent. Incidentally, the rationale for such supplementation has been worked out, including the increase in palatability and acceptability of the end product. Furthermore, UNICEF has actually supplied two small plants to initiate such a program. I regret to tell you, however, that progress has been slow in putting this proposal into practice.

Recognition based on extensive recent nutritional and pediatric research, that such unconventional protein resources might have nutritive value even for infants, has now focused attention on the question: does technology necessary to produce food-grade products exist, which can be adapted to the conditions and needs of developing countries? Until recently the processing as human foods of products such as peanut and cottonseed meals, and also fish meal, have received virtually no attention. Their nutritive quality, not to mention sanitary character, even when produced only as animal feeds, frequently leaves much to be desired. Taking cottonseed processing as an example, it has become evident that traditional methods to recover the oil are usually less than ideal for providing the protein byproduct as an edible, sanitary, and nutritious food. In the case of soybeans, traditional empirical methods for food processing are practised throughout southeast Asia. Thus, fermented soybeans such as tempeh, and soybean curds in fresh and fermented forms are excellent foods quite analogous to our own fresh dairy products. Nevertheless, for the purposes I have outlined, there exists great need for dry stable products for which processes of adequate scale did not appear to be available until only very recently. As a matter of fact, just within the past few years has there occurred some measure of agreement among pediatricians acquainted with infant feeding problems in various countries and cultures, that safe weaning foods might indeed be produced from soybeans. In this regard it is significant to recall that even soy milks, as processed by home or traditional village methods, have not been used to any significant extent for supplementary feeding and weaning of young infants even in China and Japan.

A point I wish to emphasize is that while there have existed useful technological parallels for this effort in processes used to manufacture livestock feeds, there has been little directly useful food processing experience or pertinent food science to draw upon. It is not surprising that such technology is lacking even in the economically advanced societies, simply because they have not needed it, being adequately supplied with the traditional animal proteins. The time has surely come for a broad scientific and technological effort to develop the necessary food science and processing skills upon which the rational utilization of oilseed and fish meal proteins as foods can be realized. In this context it should be emphasized that in the United States and other well-fed countries, little concern has existed for the effects of food processing on the nutri-

tional value of even those cereal and vegetable proteins which are widely used in our diets. I need refer you only to a single example--that of the tremendous use of highly heat-treated breakfast foods whose major nutritional virtue on the protein side, is that they are a vehicle for getting milk into children! While this country is fortunate enough to be able to disregard the effect of processing on the protein quality of its food supply, this is decidedly not the case in developing countries whose best protein resources may be the cereals, the legumes, and similar plant materials.

But, you may ask, why do I emphasize a need for processed foods in poor, underdeveloped countries? Why stress industrial processes which would apparently increase food costs at a time when many people of a developing country hardly participate at all in a money economy?

The answer to the first question is inherent in what I have already said, namely that raw materials such as cottonseed with its toxic constituents including gossypol and malvalic acid, soybean with its variety of toxic antibiological factors, and peanut which is susceptible to fungal toxicity, all need more specialized industrial-type processing to render them useful as human food, than the comparable requirements of traditional proteins such as milk, meat, and eggs, from which virtually all deleterious factors have been effectively filtered out for us by passage through an animal. Industrial-scale processing must therefore perform with these plant proteins what the animal performs, but of course at a much smaller loss in useful nutrients.

As for the economic justification for processed foods, it now appears that the most serious problem of developing countries is less related to the needs of the rural or subsistence population, which survives as best it can on largely what it produces by itself, than it is to the needs of the trememdously increasing number of urbanized low-income people who are flocking to the cities and towns throughout continents such as South America and Africa. These people, earning their livelihood as workers in industry or trade, must purchase whatever food they eat, and the new challenge then is to supply their needs for sanitary, economically packaged, nutritious products through regular trade channels, hopefully at a price which they can afford to pay. The challenge then is to develop technology--and the kind of food science necessary to support it--that will accomplish such processing in the most economical ways, consistent with the best sanitary and nutritional practices, and on a scale adapted to the needs of developing countries. In planning for such technological needs it must be kept in mind that in such areas labor is usually abundant and capital is invariably scarce. Clearly therefore, U.S. industrial processes, developed generally with precisely the opposite considerations in mind, usually have little relevance, without considerable modification or adaptation, to the needs of a developing country. In spite of a preoccupation with more grandiose aspects of economic development, a few scientists and technologists in developing countries are beginning to appreciate this point and to lay their plans accordingly. UNICEF and other agencies are supporting such effort, but its scope is pitifully inadequate in terms of the need.

These then are some of the broad considerations of the WHO/FAO/UNICEF Protein-Rich Foods program as it has been called, and the ways in which it attempts to assist Governments in developing and marketing processed low-cost foods meeting the nutritional and economic needs of low-income consumers. I am happy to say that progress is beginning to appear in this difficult work. For example, the Quaker Oats Company in Colombia after only a little more than one year of introduction, is already marketing 200 tons per month of Incaparina, which is a low-cost mixture of corn, soy, and cottonseed flours. The Nestlé Company in Brazil is marketing a similar product called Fortifex. Other companies are preparing to enter this field in several countries. The international agencies are helping by various means to introduce these new foods and to encourage their manufacture and marketing. We are exploring in collaboration with other agencies various small-scale technologies for producing fully heat-processed food mixtures of various types.

I should like to close by complimenting our friends in the Agricultural Research Service of USDA on the remarkable way they have accepted the challenge posed by these problems and in moving ahead to allot resources and manpower to their solution. In the area of new methods for processing soybean as food, excellent progress has already been made at the Northern Regional Research

Laboratory, as Mr. Griffin will report. UNICEF is pleased that we have been able to collaborate with this excellent work. To the Southern Regional group must go major credit in resolving problems in processing and quality control of peanut and cottonseed protein concentrates. UNICEF has also had the privilege of participation with this group. We are pleased to know that the new Human Nutrition Division of the Agricultural Research Service in Beltsville has already achieved progress in studying useful recipes and formulations using some of these new foods. I look forward to discussing personally with some of you the major challenges in sciences and technology which have yet to be met in this field, as well as in the even larger area of food production by nonconventional and even, if you please, nonagricultural methods.

FOOD POISONING

by
G. M. Dack, M. D.
Food Research Institute and Department of Microbiology
University of Chicago
Chicago, Illinois

Modern food processing is a highly competitive business. Supermarkets carry, in addition to staples, foods preserved in many different ways, i.e., by canning, freezing, freeze-drying, and dehydration. There are approximately 8,000 items available in today's supermarkets (9). In order to be able to add new products, room must be made on the shelves by replacing less acceptable commodities. For a food industry to grow, it is necessary to introduce new products which have a general public appeal and which require little preparation in the home. They are frequently referred to as "convenience foods."

In developing new convenience foods for the market, the processor must guard against introducing health hazards. There are many microbial agents that may cause food-borne illness. Dr. Senti has already discussed the problem of mold toxins. Bacteria of public health importance include six types of Clostridium botulinum, four or more types of enterotoxigenic staphylococci, the 800 or more serotypes of Salmonella, and the vibrios. Also included are widely different microorganisms, such as Clostridium perfringens, enterococci, Bacillus cereus, and others.

Many outbreaks have been reported where the causative agent was thought to have been found, but could never be established. Viral agents account for some of these. A study of viral diseases has indicated that many different viruses may be associated with food-borne illness; some of them giving rise to gastrointestinal symptoms that may be confused with symptoms being caused by bacterial agents.

There are no accurate records as to the number of food-borne illnesses occurring in the United States. This is due to the fact that such illnesses are not reported by physicians unless large groups of individuals are affected simultaneously.

Botulism. There are six types of toxin-producing Clostridium botulinum. Types A and B have their habitat in the soil, and the strains from the United States are putrefactive. The spores are very heat resistant and persist and grow in foods inadequately heat processed liberating toxin. Types A and B C. botulinum in the United States are involved most commonly in outbreaks of food poisoning in man. Only rarely have Types C and D been involved in human outbreaks.

In 1963, Type E was the cause of three commercial outbreaks of food poisoning in the United States. This organism produces spores which are not as heat resistant as those of Types A and B; it is nonproteolytic and grows at refrigeration temperatures (21). The author has not been able to obtain growth of Types A and B organisms at 50 °F.

One of the three above-mentioned outbreaks was attributed to canned tuna fish where contamination occurred, after retorting, as a result of defective sealing of the cans. There were three cases with two deaths (7). Two cases and two deaths occurred in a second outbreak due to smoked whitefish, and a third outbreak of 17 cases and five deaths was attributed to smoked whitefish chubs which had been vacuum packaged (18).

Only one outbreak, which occurred in Denmark in 1958, was caused by Type F, the vehicle being home-canned liver paste (6).

Clostridium botulinum will grow on plant or animal tissue without vacuum packaging of the product. Vacuum packaging, however, would prevent spoilage of the product from molds which do not grow in the absence of oxygen, and extend the storage life of the product. Since C. botulinum Type E is non-protelolytic, its growth in a food may not be detected.

Vacuum packaging. Frozen vegetables are sometimes combined with other vegetables and a sauce and may be put into plastic packages which are immersed in boiling water in preparation for serving. Does a botulism hazard exist in such packages of vegetables in sauce that are prepared for serving but not used and allowed to stand at room temperature? The industry is aware of this problem, and specific directions, indicating proper handling of this type of package, should be clearly written on the package in order to prevent a health hazard.

Two cases of botulism were reported from eating frozen chicken pot pies (16). In this outbreak, four commercially frozen chicken pot pies were placed in an oven and baked for the recommended time and at an adequate temperature. Subsequently, two of the four pies were consumed causing no ill effects but two were left in the oven, with a pilot light burning, until the following day when they were transported to another house and placed there in a refrigerator for four hours. They were then heated in an oven for about 15 to 20 minutes and tasted by the two patients. Because the pies had a metallic taste, only a spoonful was eaten by each. Symptoms of botulism developed in both individuals after 48 hours. Both were treated with botulinum antitoxin and recovered. The type of toxin was not determined in this outbreak since none of the food was available. Spores of Clostridium botulinum may have been present in the peas, carrots and/or the flour in the crust. Baking of the pies did not provide sufficient temperature to kill botulinum spores, but did destroy heat-susceptible, competitive micro-organisms leaving the spores of heat-resistant organisms, including C. botulinum, to grow. Toxin should be found in the product accompanying the growth of C. botulinum.

Botulinum spores naturally present in soil form part of the microbial flora contaminating vegetables, such as carrots and peas, and these spores survive blanching prior to freezing.

An outbreak of botulism due to Clostridium botulinum, Type A, involving seven persons, was associated with the consumption of home-made dill pickles by a group of teenagers eating at a restaurant at Herndon, Kansas, in November 1964 (19). Five of the seven cases were hospitalized, and one died. This is the third outbreak of botulism in the United States that was attributed to pickles; one occurred in the State of Washington in 1925 and the other in California in 1942. In both of these instances, home-canned dill pickles contaminated with Type A botulinum toxin was responsible for the illness.

Staphylococcus. Staphylococcus food poisoning is caused by the enterotoxins produced by certain strains of staphylococcus. There are at least four antigenically different enterotoxins associated with food poisoning outbreaks. Staphylococci may be inhibited in some convenience foods, such as frozen pot pies, by the natural flora in these products which may overgrow them (5). The staphylococcus enterotoxins are heat resistant as they are produced in foods in contrast to chemically purified enterotoxins that are less heat resistant.

Sixteen outbreaks of staphylococcus food poisoning were associated with canned peas in England (14). In addition to the outbreaks caused by canned peas, there were a number of canned meat outbreaks in England, principally caused by corned beef processed in Africa (15). Contamination of these products must have occurred after heat processing in cans with defective seals.

Salmonella. Salmonella outbreaks have principally been concerned with contaminated animal products, such as poultry, eggs, pork, beef, and mutton; but, they have also been caused by contamination of foods of non-animal origin.

A few outbreaks of salmonellosis have been attributed to canned foods. An outbreak of typhoid fever in England was associated with a six-pound can of ox tongue (3). More recently, an outbreak of typhoid fever was reported in Aberdeen, Scotland, involving 240 cases and was thought, although not

definitely proved, to be due to contaminated canned corned beef (24). Contaminated cooling water was used in the vats for cooling these cans after retorting, and in each instance a can with a leaky gasket must have taken in a typhoid bacillus. Large leaks would admit micro-organisms which would cause spoilage and "swells," and cans of meat so affected would be discarded. However, the typhoid bacillus would pass unrecognized, would produce no "off color" or taste, nor would it produce gas when growing in the product. The likelihood of a single Salmonella organism entering a tiny leak in the gasket of a can is extremely remote, but it does occur.

Dried foods have been frequently involved in outbreaks of disease. Cake mixes are alleged to have been the source of Salmonella cases that occurred in Canada (17, 22). In such instances, mixes containing eggs are principally the vehicle. In the author's laboratory, in 1960, dried egg white in six cake mixes picked up from the open market were found to contain Salmonella. The egg white in one mix contained 15,000 S. montevideo per gram. Since the egg albumen in a cake mix is diluted 1:3, this would represent a 45,000 per gram count of the undiluted albumen powder. As a result of the salmonellosis outbreaks in Canada, which were attributed to cake mixes, the industry now purchases egg products on bacteriological standards designed to control salmonellosis.

With modern bakery practices shell eggs are not used by the baker. The use of frozen whole egg, egg white, and dried egg albumen has replaced that of shell eggs; methods of pasteurizing whole egg and treatment of albumen to free it of living Salmonella have been developed (12).

Coconut imported into the United States and into other countries some years ago was found to be contaminated with Salmonella. Prior to 1960, S. waycross had not been encountered in Germany until it was discovered in imported coconut (25). Subsequently, S. waycross was isolated from the blood stream of two patients who had eaten a cake covered with a flour and sugar frosting containing coconut. Methods of processing coconut have now been devised to destroy viable salmonellae.

Animal byproducts, such as meat meal, bone meal, feather meal, and fish meal, have commonly been contaminated with salmonellae (10, 1, 20). Since these products are combined in feeds mixed with plant byproducts, such as cottonseed meal, peanut meal, and various cereal products, such high protein feeds are often fed to young livestock (poultry, swine, and cattle) and thus may serve as a source of salmonellosis. Young animals and debilitated older ones, like people, are much more susceptible to infection caused by Salmonella strains.

Vibrios. The Japanese have described Vibrio parahaemolyticus as a halophilic organism that grows well in peptone water containing 3.5 percent salt (23). This vibrio is responsible for hundreds of food poisoning outbreaks reported in Japan during the warm months of the year. Most of the cases are associated with eating raw seafood, although the first outbreak was related to cucumber. The symptoms of illness caused by Vibrio parahaemolyticus are almost identical with those of gastroenteritis caused by salmonellae. Many outbreaks of gastroenteritis in the United States, where the causative agent has not been determined, may have been caused by the vibrios.

Clostridium perfringens. Certain strains of Clostridium perfringens that multiply rapidly in food have been found to cause gastrointestinal symptoms usually coming on from 5 to 15 hours after a meal. Most of the outbreaks have been associated with meats which had been insufficiently cooked to destroy Clostridium perfringens spores. These organisms grew rapidly on such meats allowed to stand for several hours at a warm temperature. Adam (2) reports an outbreak involving 300 persons in Hamburg, Germany, in which the vehicle was vanilla sauce. The sauce contained 8,000,000 C. perfringens per gram and had been prepared from a commercial powder. The liquid base needed for its preparation was brought to a boil and the powder was then stirred into it. An incubation period apparently occurred providing time and temperature for the germination of the spores and growth of the organism.

Enterococci. A few outbreaks of gastrointestinal illness have been associated with foods containing large numbers of enterococci. These have been usually associated with meats, turkey dressings, and with foods which were inadequately refrigerated.

Bacillus cereus. Bacillus cereus is a common, spore-forming organism whose

habitat in nature is the soil. Foods containing many millions of B. cereus per gram have been associated with gastrointestinal illness. The author is familiar with an outbreak that occurred in a hotel where people, attending a dinner, developed abdominal cramps and diarrhea as the principal symptoms from 8 to 15 hours after the meal. The incriminated food was mashed potatoes that had been prepared from a dehydrated product; Bacillus cereus numbered 60 million per gram. The dried potatoes, from which the mashed potatoes were prepared, contained only 13,000 organisms per gram; obviously, the dilution of the dried potatoes with water and the cooking would not account for the increase of numbers of bacteria in the end product and only mis-handling, at incubation times and temperatures favorable to bacterial growth, can explain such a result.

Viruses. There are many outbreaks of gastrointestinal disturbances for which no chemical or bacterial agents have been found. With the development of tissue culture methods for the isolation of some viruses, it is hoped to demonstrate them in implicated foods involved in food-borne illnesses in which causative bacterial agents were not found.

Frozen, concentrated orange juice, when first marketed, was considered by some public health workers as a potential carrier of pathogenic bacilli (4). This was due to the fact that coliform bacilli were found in small numbers in the product. Since frozen concentrated orange juice does not support the growth of enteric bacteria and since it has not been associated with outbreaks of shigellosis or salmonellosis, it has been regarded as one of the safest products from the point of view of food-borne disease.

The viruses, however, do not share identical properties with enteric bacilli, and an outbreak of infectious hepatitis occurred involving hospital nurses; it was attributed to orange juice prepared from concentrated frozen juice contaminated by a carrier of infectious hepatitis (8). Some of the enteric viruses, of which the virus of infectious hepatitis is an example, are not killed at pH 3 (13). The virus of infectious hepatitis contaminating orange juice will not multiply in the product, and there is great need for more information as to how long viruses may persist in an infectious state in such a food product. Liebhaber et al. (11) recovered a cytopathic agent from the urine of a patient with infectious hepatitis. The virus was isolated and propagated in cultures of human diploid lung fibroblasts. This virus was stable at pH 3 and in 80 percent serum at 56° C. when heated for 30 minutes.

In summarizing, the introduction of many convenience foods into the markets has brought with it public health problems. Modern methods of canning, freezing, dehydration, and freeze-drying have resulted in global distribution of food. Processing methods are sometimes developed without giving sufficient thought to public health hazards that may occur. These hazards are not always circumvented by the use of modern equipment and sanitation. A solution to these problems is attainable but may, however, involve the establishment of microbiological standards for the raw products used in convenience-food processing plants.

References

(1) Adam, W., "Uber die Herstellung und Pasteurisierung von Fischmehl im Hinblick auf dessen Gehalt an Salmonellabakterien." Berlin. & Munch. Tierarztl. Wchschr. 70, 49-51 (1957).

(2) Adam, W., "Über Massenerkrankungen an Lebensmittelvergiftungen durch Pudding infolge Befalls mit Clostridium perfringens." Desinfektion & Gesundheitswesen 2 (1958).

(3) Couper, W.R.M., Newell, K.W., and Payne, D.J.H. "An outbreak of typhoid fever associated with canned ox-tongue." The Lancet, June 30, 1956, pp. 1057-1059.

(4) Dack, G.M., "Significance of enteric bacilli in foods." Am. J. Public Health, 45, 1151-1156 (1955).

(5) Dack, G.M. and Lippitz, G., "Fate of staphylococci and enteric micro-organisms introduced into slurry of frozen pot pies." Appl. Microbiology, 10, 472-479 (1962).

(6) Dolman, C.E. and Murakami, L., "Clostridium botulinum Type F with observations on other types." J. Infect. Dis., 109, 107-128 (1961).

(7) Eadie, G. A., Molner, J. G., Solomon, R. J., and Aach, R. D., "Type E botulism. Report of an outbreak in Michigan." JAMA, 187, 496-499 (1964).

(8) Eisenstein, A. B., Aach, R. D., Jacobsohn, W., and Goldman, A., "An epidemic of infectious hepatitis in a general hospital. Probable transmission by contaminated orange juice." JAMA, 185, 171-174 (1963).

(9) Food Protection Committee of the Food and Nutrition Board, National Academy of Sciences--National Research Council. An evaluation of public health hazards from microbiological contamination of foods. Publication No. 1195, Washington, D. C. (1964).

(10) Hansen, R., Jacobs, N. J., Wilder, O. H. M., and Niven, D. F., Jr., "Studies on the control of Salmonella contamination in rendered animal by-products." Am. Meat Institute Foundation, Bulletin No. 53, (December 1962).

(11) Liebhaber, H., Krugman, S., Giles, J. P., and McGregor, D. M., "Recovery of cytopathic agents from patients with infectious hepatitus: Isolation and propagation in cultures of human diploid lung fibroblasts." Vorology, 24, 109-113 (1964).

(12) Lineweaver, H. and Cunningham, F. C., "Heat stability of egg white and egg white proteins." Presented at the 24th Annual Meeting of the Institute of Food Technologists, Washington, D. C., (May 24-28, 1964).

(13) Melnick, J. L., Wenner, H. A., and Rosen, L., Chapter V. "The Enteroviruses" in "Diagnostic Procedures for Viral and Rickettsial Diseases," 3rd, ed. (1964). Editors, E. H. Lennette and N. J. Schmidt. American Public Health Association, Inc., New York.

(14) Monthly Bulletin of the Ministry of Health and Public Health Lab. Service, 17, 252-263 (1958).

(15) Ibid. 20, 160-171 (1961).

(16) Morbidity and Mortality Weekly Report, Public Health Service, U. S. Department of Health, Education, and Welfare, Vol. 9, No. 27, (July 15, 1960).

(17) Morbidity and Mortality Weekly Report, Public Health Service, U. S. Department of Health, Education, and Welfare, Vol. 10, No. 51, (December 29, 1961).

(18) Morbidity and Mortality Weekly Report, Public Health Service, U. S. Department of Health, Education, and Welfare, Vol. 13, No. 1, (January 10, 1964).

(19) Ibid. Vol. 13, No. 48, (December 4, 1964).

(20) Röhr, W., "Salmonellen in Futtermitteln." Monatsh Vet. Med. 15, 296-301 (1960).

(21) Schmidt, C. F., Lechowich, R. V., and Folinazzo, J. F., "Growth and toxin production by Type E Clostridium botulinum below 40°F." J. Food Science, 26, 626-630 (1961).

(22) Skoll, S. L. and Dillenberg, H. O., "Salmonella thompson in Cake-Mix." Canad. J. Public Health, 54, 325-329 (1963).

(23) Takikawa, I., "Studies on pathogenic halophilic bacteria." Yokohama Med. Bull., 9, 313-322 (1958).

(24) "Typhoid at Aberdeen." Brit. Med. J. 1, 1500-1501 (1964).

(25) Winkle, S., Rohde, R., and Adam, W., "Salmonella-befallene Importierte Kokosraspeln als eine weitere gefahrliche Infectionsquele." Zentralbl. Bakt. & Parasitenk. Orig. 1. Abt., 179, 583-586 (1960).

PRESENT DAY CONCEPTS OF FATS IN THE DIET

by
G. A. Goldsmith, M. D.
Tulane University School of Medicine
New Orleans, Louisiana

In recent years, relationships between dietary fat and atherosclerosis have been widely discussed. However, we still do not know the amount and kind of dietary fat that

is desirable for maintenance of good nutrition and health. The average American probably eats too much fat; it furnishes 40 to 45 percent of the daily intake of calories. About one-third of this fat comes from dairy products, one-third from fats and oils and one-third from meat, poultry and fish. The fatty acid content is 42 percent saturated, 41 percent monounsaturated and 17 percent polyunsaturated.

Fat has a number of important functions in the body. It is an essential component of all living tissue and an integral part of cell structure and function. It forms our most important source of energy furnishing 9 calories per gram. Furthermore, energy is stored in the body largely as fat. Fat also provides the fat soluble vitamins A, D, E, and K. It insulates and protects the whole body and the organs against trauma. It increases the palatability and satiety value of the diet and enhances the efficiency of utilization of carbohydrate and protein.

While fat can be manufactured from the other energy producing foodstuffs, the diet must contain certain essential fatty acids which the body cannot manufacture, namely, linoleic and arachidonic acid. It has been found that the requirement for these fatty acids is about 1 to 2 percent of calories. They normally account for a large part of the fatty acids of cholesterol esters and phospholipids found in blood serum. A high intake of the essential fatty acids decreases serum cholesterol levels. It has been hypothesized that these acids are needed for normal cholesterol transport. Essential fatty acids have been shown to be prominent constituents of mitochondrial lipoproteins. Essential fatty acid deficiency has been observed in human infants. Such deficiency is characterized by abnormalities of the skin and an abnormal polyunsaturated fatty acid pattern in serum.

The fat soluble vitamins, which are ingested in diet in conjunction with fat, have important body functions. Vitamin A is necessary for vision in dim light and has a role in the maintenance of normal epithelium. Vitamin D is important in calcium and phosphorus metabolism and is essential for normal bone formation. Vitamine E is an antioxidant. It retards oxidative rancidity of polyunsaturated fatty acids in the tissues. It is also an essential component of mitochondrial lipoprotein membranes. Vitamin K is needed for normal coagulation of blood.

There are three important types of dietary lipids. The triglycerides, which we usually think of as ordinary dietary fat, are comprised of fatty acids and glycerol. Phospholipids are more complicated in structure being made up of esterified fatty acids, phosphate and usually a nitrogenous base. The sterols include cholesterol and sitosterol, the former being the sterol in the animal body and the other that found in plants. The function of phospholipids is only partially known. They form structural components of cell walls and mitochondria. They are important in the digestion of fats and their emulsifying properties assist in lipid transport. They are known to participate in blood coagulation.

Cholesterol is a normal body constituent. It is manufactured principally in the liver, and to a lesser extent in other parts of the body, and it is also found in various foods. There has been a great deal of discussion about the undesirable effects of high serum cholesterol concentrations but little attention has been paid to the normal functions of cholesterol. It is probably a precursor of the steroid hormones which perform very important functions in the body. It is broken down or degraded to form bile acids which are essential in the normal digestion of fat.

The normal or desirable concentration of lipids in serum is not known. In a presumably normal, healthy individual, total fatty acids measure about 300 mg./100 ml., of which 45 percent are in phospholipids, 35 percent in triglycerides, 15 percent in cholesterol esters and 5 percent free. The last mentioned group are an important source of energy for the body. Serum triglyceride concentrations during fasting are 100±35 mg./100 ml. and serum cholesterol levels 200±40 mg./100 ml. in young adults in the third decade. Serum phospholipids in this age group measure 100-400 mg./100 ml. Serum cholesterol levels tend to increase with age, particularly in males prior to the age of 50. They increase in females after the menopause.

It has been suggested that a number of dietary factors are related to atherogenesis in man. The following dietary substances have been shown to influence serum lipid concentrations: the total fat content of the diet, the amount of saturated as compared to unsaturated fat in the diet, the percent of polyunsaturated fatty acids ingested, the amount and type of dietary protein, the

amount and kind of carbohydrate in the diet and the presence of plant sterols. Some of these factors increase and some decrease serum lipid levels. Those that increase levels of cholesterol, triglycerides, phospholipids and betalipoproteins are postulated to have an influence on the development of atherosclerosis and coronary artery disease with coronary thrombosis. Other dietary factors which may influence serum lipid levels include fatty acids of varying chain lengths and configurations, dietary cholesterol, vitamins, especially vitamin B_6, several minerals and even the fiber content of the diet.

Medical investigations have indicated that an increased incidence of atherosclerosis and coronary artery disease is associated with the following findings: a family history of vascular disease, obesity, high blood pressure, and elevation of serum lipids, i.e., hypercholesterolemia, hypertriglyceridemia, hyperbetalipoproteinemia and prolonged lipemia after meals. Heavy smoking, physical inactivity, and a hypomaniac personality pattern also appear to be associated with an increased incidence of coronary artery disease. Certain medical disease states are also related to atherosclerosis, that is, diabetes mellitus, hypothyroidism and some types of damage to the kidney. Physicians often speak of coronary prone patients. These include patients who have hypertension, obesity, elevation of serum cholesterol levels and a family history of cardiovascular disease.

Studies that relate plasma cholesterol concentrations to atherosclerosis may be briefly summarized. Epidemiological studies in various parts of the world show a correlation between hypercholesterolemia and coronary artery disease. Clinical studies of patients with diabetes mellitus, hypothyroidism, xanthomatosis and nephrosis show that in these diseases serum cholesterol is elevated and there is also a high incidence of coronary atherosclerosis. Studies in experimental animals have shown that atherosclerosis can be produced only by the inducation of hypercholesterolemia. From a pathological and biochemical standpoint, cholesterol and other lipids are found in atheroma, the lesion which develops in blood vessels and causes a narrowing of the lumen. However, in spite of all these associations, atherosclerosis is not always accompanied by hypercholesterolemia, and hypercholesterolemia is not always followed by atherosclerosis. Interesting epidemiologic data were reported by Jolliffe and Archer (1). They found that the death rate of degenerative heart disease showed a positive correlation with the percent of saturated fat in the diet, the percent of animal protein intake and the percent of fat as total calories. They also found a positive correlation between the number of telephones per 100 persons and this type of heart disease. There was a negative correlation with the percent of calories as unsaturated fat in the diet.

If elevated serum cholesterol levels are undesirable, and considerable evidence indicates that this may be the case, then an understanding of the factors controlling the concentration of serum cholesterol is necessary if methods to lower the levels of this fatty substance are to be devised. The concentration of serum cholesterol is the resultant of the amount absorbed from the diet plus reabsorption of cholesterol put out in the bile and the amount synthesized in the body, as related to the amount of cholesterol excreted in the stool, as cholesterol or as its degredation product bile acids, and the amount utilized or stored in the tissues. With these facts in mind, what are mechanisms by which serum cholesterol, and also other serum lipids, can be lowered? The dietary supply can be reduced or the absorption of lipids can be prevented or decreased. The synthesis of cholesterol or other lipids in tissue can be inhibited. The degradation or breakdown and excretion of lipids can be enhanced or there may be redistribution of lipids between the serum and the tissues, more being deposited in the various organs of the body. Use has been made of most of these mechanisms in treating persons with high serum lipid concentrations.

From the standpoint of medical therapy, it may be desirable to attempt to lower both serum triglyceride and serum cholesterol concentrations under certain circumstances. High serum triglyceride concentrations as well as hypercholesterolemia have been related to atherosclerosis and coronary artery disease. There are two types of hypertriglyceridemia. One is induced by high fat diets. Obviously, the treatment of this condition would be a low fat diet, one in which fat furnishes only 10 percent of the calories. Unfortunately, this is not a very palatable regimen. The second type of hypertriglyceridemia is induced by carbohydrates. This is treated by a relatively high fat diet

in which fat furnishes 35 to 40 percent of the calories. The fat in this diet should be rich in polyunsaturated fatty acids as this will result in a decrease in serum cholesterol as well as triglyceride levels.

There are several methods of treating hypercholesterolemia with diet. The total fat intake and the amount of cholesterol ingested can be markedly reduced. However, a more satisfactory reduction of serum cholesterol can be obtained by a diet containing moderate amounts of fat, 30 to 35 percent of the calories, when a large percentage of the fat, 33 to 50 percent, is obtained from polyunsaturated fatty acids. With this type of dietary regimen, serum cholesterol concentrations decrease 10-25 percent and, in some patients, even more than this. In an occasional subject, polyunsaturated fat does not influence serum cholesterol concentrations.

What foods are included in a diet in which polyunsaturated fat has been substituted for saturated fat? The content of vegetable oils, corn, cottonseed, soy or safflower, is increased and special margarines and shortenings are used that are only partially hydrogenated and contain larger amounts of unsaturated fatty acids. These polyunsaturated sources of fat are used in baking, frying, salad dressings, on vegetables and even taken as such in tomato juice. In order to reduce the saturated fat in the diet, only nonfat milk and no cream is included. Only lean meats are permitted and fish and poultry are used more frequently than in the ordinary diet. Only four eggs per week are allowed. No commercial bakery goods except bread can be taken by the patient. He should avoid chocolate or caramel type candies made with cocoa butter. Good, palatable diets adequate in all nutrients can be obtained with a regimen such as this.

The mechanisms by which polyunsaturated fats lower serum cholesterol levels is not known. There is some evidence that they may increase the excretion of sterols and bile acids in the feces. Perhaps the breakdown of cholesterol to bile acids is accelerated. They may also influence the intestinal flora thus affecting the structure of sterols and bile acids and influencing reabsorption of these materials.

From a medical or health standpoint, when should an attempt be made to substitute polyunsaturated for saturated fats in the diet? This would seem to be desirable in coronary prone patients who have been described above. When persons have elevated serum lipid levels, in view of possible relationships to the development of atherosclerosis, attempts should be made to lower these toward normal. What about recommendations for the general population? In my opinion, we do not have sufficient information to recommend any change in the American diet to the general public at the present time. Specific dietary recommendations remain an individual problem and should be carried out under the supervision of a physician. It will probably take many years of research before the relationships between dietary fat, and other substances in the diet, and degeneration of the blood vessels and heart disease can be clearly delineated.

References

(1) Jolliffe, N., Circulation 20 (1): 109-127 (1959).

A CHEMIST'S LOOK AT THE FUTURE SOURCES OF FOOD

by
A. T. McPherson
Institute for Applied Technology
National Bureau of Standards
Washington, D. C.

A chemist, looking at the world food and population problem, can see the possibility of making food quickly and efficiently from petroleum or other readily available raw materials through chemical or biochemical synthesis. He can see, through a crash program, the prospect of closing the gap between the food supply from agriculture on the one hand, and adequate nutrition for all peoples of the world on the other hand, within a very few years.

In a recent publication of the Freedom from Hunger campaign (2), an authority of the United Nations' Food and Agriculture Organization looks forward to attaining minimum standards of adequate nutrition in the food-deficient countries by the year 2000.

But will the hungry two-thirds of the world's population wait until the year 2000?

The food riots in India show that they will not wait.

These riots have been temporarily checked by large shipments of United States grain, but our surplus food cannot long stem the tide because in 15 years the population of India will have increased by a number equal to the entire population of the United States, and India is only one of a number of countries looking to our food surplus.

New future sources of food are urgently needed in addition to all the increase that can be attained by the expansion and improvement of conventional sources.

In order to ascertain the feasibility of synthesis as a source we shall undertake to answer the following basic questions:

Requirements -- What specific foods should be provided for the diet-deficient countries in order to meet minimum standards of adequate nutrition?

Raw materials -- What raw materials are available and suitable for the production of the particular foods that are needed?

Production -- What methods of production can be used? What time schedule should be set?

Acceptance -- How can we insure that the new synthetic foods will be readily accepted and used?

I. Requirements to Fill the Food Gap

The present and prospective food supplies of the different countries of the world have been estimated by experts of the United Nations, the U.S. Department of Agriculture (3) and other organizations. By comparing these figures with the minimum standards for human nutrition, taking into account the increase in population of the different countries, estimates have been made as to the amount and kind of food that would be required to provide an average minimum diet for the diet-deficient countries.

The U.S. Department of Agriculture's "World Food Budget 1970" and other studies indicate that the major deficiencies are two,--calories to provide energy, and animal protein or its equivalent to supply material for the growth of the young and the maintenance of body tissues of the adult.

Calories

The major sources of calories in the human diet are carbohydrates and fats. The food-deficient countries obtain 78 to 80 percent of their calories from carbohydrates whereas the affluent countries obtain about 40 percent of their calories from fat, and consume about three times the amount of fat called for by a minimum diet, indicating a strong preference for a high percentage of fat in the diet, even though it may not be essential.

Because of this evident preference, plans to furnish additional calories in the diet will be based on providing all of the needed additional calories in the form of fats or fatty acids. No consideration will be given at this juncture to the production of edible carbohydrates from cellulose, although this would be a possible and practical means of supplying the additional calories. The total amount of fat that would be required for the diet-deficient countries is shown in table 1. Computations have been made on the basis of data for 1959-1961 and also from projections to 1970 given in the U.S. Department of Agriculture's "World Food Budget 1970". These computations neglect the relatively small number of additional calories that would be supplied by the supplementation of the protein in the diet. The total amount of fat required would be about 30 million metric tons a year on the basis of the 1959-1961 figures, but only about 20 million tons if the gains in production exceed the growth of population under the assumptions made by the Department of Agriculture.

Animal Protein

The amino acids required to make up the animal protein deficit vary considerably depending on the standard that is set and the estimates of increased production of pulse proteins, it being assumed that the latter will

Table 1. --Food Required to Meet the Calorie and the Animal Protein Deficits in the Diet-Deficient Countries

Item	Years 1959-1961	1970
Population, in millions	1,923	2,373
Calories, per person per day		
Food from conventional sources	2,033	2,203
Standard diet	2,400	2,400
Calorie deficit	367	197
Synthetic fat to supply calories		
Per person per day, grams	40.8	21.8
Entire population, millions of metric tons per year	28.6	18.9
Animal and Pulse protein, per person per day, grams		
Food from conventional sources		
Animal protein	7.2	8.6
Pulse protein	8.6	10.0
Standard, U.S. Department of Agriculture		
Animal protein	10	10
Pulse protein	10	10
Target, Food and Agriculture Organization		
Animal protein	16	16
Deficit, U.S. Department of Agriculture		
Animal protein	2.8	1.4
Pulse protein	1.4	0.0
Deficit, Food and Agriculture Organization		
Animal protein	8.8	7.4
Synthetic amino acids or protein to supply protein deficit, millions of metric tons per year, based on estimates by--		
U.S. Department of Agriculture	2.9	1.2
Food and Agriculture Organization	6.2	6.4

satisfy part of the need for animal proteins. The Department of Agriculture budget would provide the diet-deficient countries with 60 g. of total protein per person per day; 10 g. of this would be animal protein and 10 g. pulse protein. On the basis of 1959-1961 data the desired amino acid production to make up the animal protein deficit would be 3 million metric tons per year, in round numbers. However, 6 million tons would be required to meet the target of 16 g. of animal protein per person per day, set by the United Nations' Food and Agriculture Organization (1). For 1959-1961 the consumption of animal protein in the United States was 63.8 g. per person per day, or four times the goal of 16 g. set by the Food and Agriculture Organization. As a matter of fact an estimate of 20 g. per person per day is used by Pawley (2) in a basic study of the Freedom from Hunger Campaign as a goal to be reached by the year 2000. To realize this goal by 1970 would require an amino acid supplement of 9.9 million metric tons per year.

It is assumed that the amino acid production would consist of the eight or ten essential amino acids in the optimum proportion, and that a mixture of these amino acids would be equivalent to the same quantity of animal protein. The amino acid requirement would be reduced to the extent that specific amino acids such as methionine or lysine would be used to supplement incomplete cereal proteins and render them equivalent to animal proteins.

II. Raw Materials

Inasmuch as food is the source of energy for the human machine, a chemist's first

concern in looking at the calorie requirements and the present calorie deficit is to compare the energy provided by all of the food in the world with the energy supply of the world derived from other sources, particularly the energy supply derived from fossil fuels since they are the most readily available and the most immediately practical raw materials from which to synthesize food.

Sources of Calories

The food energy of the world for the diet-adequate and the diet-deficient countries is summarized in table 2, together with estimates of the deficit. Table 3 summarizes the more important world sources of energy. The values of energy are in calories representing the heat of combustion of the food and the fuel under standard conditions; they do not represent the useful work done by the energy furnished by either the food or the fuel.

For 1959-1961 the energy supplied by food was $2,606 \times 10^{12}$ cal. per year as compared with $28,703 \times 10^{12}$ cal. obtained from fossil fuels, the food energy being about 9 percent of the energy of the coal, lignite, crude petroleum, and natural gas combined. The deficit for that period amounted to 258×10^{12} cal. which, in round numbers, represents one percent of the energy of all fossil fuels and two percent of the energy of the crude petroleum and natural gas which might be used as sources of the synthetic fats to be synthesized to close the calorie gap.

Table 2. --World Food Energy

Item	Years 1959-1961	1970
Population, millions		
Diet-adequate countries	1,089	1,244
Diet-deficient countries	1,923	2,373
Calories per person per day		
Diet-adequate countries	2,941	3,023
Diet-deficient countries	2,033	2,203
Food energy per year (unit, 10^{12} cal.)		
Diet-adequate countries	1,169	1,372
Diet-deficient countries	1,427	1,908
Total	2,606	3,280
Additional food energy needed in diet-deficient countries		
Calories per person per day	367	197
Calories per year, entire population (unit, 10^{12} cal.)	258	171

Table 3. --World Sources of Energy, 1959-1961

	Energy per year (Unit, 10^{12} cal.)
Food consumed by human beings	2,606
Coal and lignite	14,847
Crude petroleum	9,577
Natural gas	4,279
Total fossil fuels [1/]	28,703
Hydroelectricity	585
Photosynthesis by land vegetation [2/]	38,700
Solar energy reaching the land [2/]	224,000,000

1/ The data for fossil fuels have been taken from "World Energy Supplies, 1959–1962," United Nations Statistical Papers, Series J, No. 7, United Nations, New York, 1964.

2/ The data for photosynthesis and solar energy are from Thirring, "Energy for Man," p. 262, Indiana University Press, 1958.

The conversion of hydrocarbons to fatty acids and fats can be made with a relatively high yield, but even if only 50 percent efficiency should be obtained the amounts of fossil fuels required would be small relative to their use for other purposes. The estimates of the Department of Agriculture for the increased production of food by conventional methods and the rapidly increasing production of fossil fuels would make the requirements for supplementary food calories for 1970 a much smaller fraction of the fossil fuel production than as shown by the 1959-1961 figures. Far more than the necessary amount of fossil fuel could be saved by the setting of

carburetors of automobile engines for maximum efficiency rather than maximum power, as at present.

Source of Fixed Nitrogen

The direct chemical synthesis of essential amino acids to supplement the incomplete cereal proteins and to make up the animal protein deficit would, according to presently available methods, proceed from petroleum hydrocarbons and ammonia derived from the fixation of atmospheric nitrogen. The petroleum, as has been shown, is in adequate supply, and only a small fraction of the world production of ammonia would be required.

The average total daily consumption of protein of all kinds is 64 g. per person per day. Taking the factor 6.25 as the ratio of protein to nitrogen, the protein in the diet is equivalent to 10.2 g. of nitrogen per person per day. The total amount of nitrogen in human food for a year would then be 11.3 million metric tons. This is somewhat more than the world production 10.27 million metric tons of synthetic ammonia in 1959-1961. The production of 10 million tons of amino acids a year, according to the maximum estimate of the need, would require 1.6 million tons of nitrogen in the form of ammonia. The world production of synthetic ammonia is increasing rapidly, and the 1964 annual capacity is estimated at about 20 million tons, on the basis of nitrogen, so that the largest requirement to make up the protein deficit for 1970 would take considerably less than 10 percent of the available supply.

Sources of Minerals

Sulfur, phosphorus, calcium, iron, iodine, and other mineral elements that might be required for the production of synthetic food would be needed in quantities that would be so small in comparison to other uses as to interpose no problems of supply.

III. Production

The current production of synthetic foods and related materials in the United States consists of vitamins, amino acids, and materials for flavor and perfume, as shown in table 4. Amino acids are of the greatest interest. Only two are produced in quantity -- methionine which is quoted at $1.10 per lb. in car load lots in the feed grade, and lysine monohydrochloride which sells for $3.90 per lb. The other essential amino acids are available in laboratory quantities at prices from $17.00 to $40.00 per lb. Flavors and perfumes have not been separated because some substances serve both purposes. However, about a third of the total production is represented by monosodium glutamate which is used as a condiment.

Table 4. --Synthetic Food Production and Sales in the United States in 1963 1/

Product	Production (1,000 lb.)	Sales (1,000 lb.)	Value ($1,000)
Amino acids	3,057	3,283	4,256
Flavor & Perfume materials	73,768	67,014	77,386
Vitamins	14,874	10,519	64,474

1/ Statistics from "Synthetic Organic Chemicals, United States Production and Sales, 1963," U.S. Tariff Commission Publication 143, U.S. Government Printing Office, 1964.

No statistics are available as to the biochemical production of protein-containing animal feed from petroleum. It is likely that only experimental quantities are being made at this time.

Direct Chemical Synthesis vs. Biochemical Production

Two methods are envisioned for the production of food from petroleum, -- direct synthesis and production by bacteria or molds growing on an emulsion of petroleum in a solution of inorganic salts. Biochemical synthesis is distinguished from the culture of algae or the hydroponic growing of plants by the fact that the energy for the biochemical synthesis is derived from petroleum rather than from sunlight. A great deal of research is currently being conducted by oil companies, universities, and others on the growing of microorganisms having a high protein content.

As an illustration of work in progress, the British Petroleum Company is reported as operating a plant at its Lavera site in France at which 500 tons a day of heavy gas oil is processed to yield 50 tons of dry, cellular material rich in protein and 450 tons of up-graded gas oil. The cellular material, described as a tasteless, white, dry powder, is being used in feeding experi-

ments. Additional experimental production is planned for Nigeria.

Biosynthetic methods possess the advantage that by the selection of organisms it may be possible to obtain a food product containing the essential amino acids in the optimum proportion, together with vitamins necessary for human nutrition. In the long term biosynthetic methods may, however, occupy only an intermediate step between the agricultural production of food on the one hand, and the direct synthesis on the other. An indication of this is given by the fact that the one time production of a variety of substances such as alcohol, acetone, and butanol by fermentation processes is being superseded by direct synthesis because the latter is the more economical.

Technique of a Crash Program

The development of a major synthetic food industry would take many years if it should follow the lines of normal commercial development, but it would be possible to telescope the development into a very few years if there should be a determination to do so. Laboratory research, process development, pilot plant operations, and studies on utilization might be undertaken simultaneously. By stopping short of large scale production the costs would be small in proportion to the magnitude and importance of the project or the total expenditure involved. Furthermore, the additional costs involved in conducting different stages of development side by side might be offset by the interest, enthusiasm, and new ideas generated by a group of scientists and engineers working under pressure to solve a major world problem.

Manpower for the Program

The critical manpower requirement would be for the initial research and development operation. By assigning high priority to the program the best available personnel could be drafted for participation in specific phases. The actual production operations would not call for large numbers of persons because the highly automated production units would be replicated as needed, and the engineers and technicians required would be given standard training courses to fit them for their respective tasks.

Time Scale

The large scale synthesis of fats, amino acids, and other materials, and biosynthesis of proteins by use of microorganisms, would be a task for the chemical industry today that would be roughly comparable to the task that the industry faced in the production of synthetic rubber in World War II. At that time production was under way in less than two years and the maximum output, in about 4 years.

Since the large scale synthesis of food would almost necessarily be an international operation, more time should be allowed for administrative arrangements and financing. There is no reason, however, why research and development could not be carried to the point at which large scale production could be undertaken by 1970. By replicating facilities for production at a number of points, particularly in the developing countries, it should be possible to close the food gap by 1980, even assuming that the social scientist, by that time, may have made only a small beginning in checking the birth rate.

The developing countries, even the smallest, are greatly concerned now with the acquisition of computers, steel mills, and nuclear reactors as status symbols. If synthetic food factories could be added to this list of status symbols, there would be no difficulty in meeting early production schedules.

IV. Acceptance

In addition to serving as a source of energy and providing material for growth and maintenance, food serves a third function that should not be passed over lightly, -- it affords pleasure and satisfaction in eating. Synthetic foods should have the mechanical and organoleptic properties that would make them sought after rather than merely tolerated.

Fortunately the substances that contribute taste and odor to food are, for the most part, relatively simple in structure so that it should not be a difficult task for the chemist to synthesize those that have not already been synthesized. Where "artificial" flavors do not exactly match those of the natural product it is because the chemist has not taken the

trouble to duplicate and include certain minor constituents. Furthermore, it is possible for the chemist to produce many pleasing flavors not known in nature.

The polymer chemist who has produced an almost endless variety of fibers, gels, gums, resins, and plastic products would encounter no major difficulty in incorporating synthetic food materials in products of nearly any desired consistency or texture, and could prepare highly acceptable counterparts of steak, jello, cheese, or seafood.

In brief, the approach in presenting synthetic food to the world would be that of offering something new that possesses health-giving properties as well as a supremely delectable taste, odor, consistency, and texture. If the chemist should do his job with imagination as well as sound technology there would be no need for the collaboration of Madison Avenue in the program.

V. Conclusion

The chemist now has the knowledge and the ability to produce from available raw materials enough food to provide adequate nutrition for everyone in the now hungry two thirds of the world population. Furthermore, the chemist can do it within a very few years, -- say, 5 years to begin large scale manufacture, and 10 years longer to close the food gap.

This now is only an idea -- a very visionary idea to some. To bring the idea to realization will require large scale cooperation and support on the part of governments of a number of countries and the United Nations. Manpower, materials, and a great deal of money will be needed -- but only a portion of the manpower, materials, and money that are now being spent on military preparations.

References

(1) Cook, R. C., Population and Food Supply, Basic Study No. 7, Freedom from Hunger Campaign, Food and Agriculture Organization of the United Nations, Rome, Italy, August 1962. (Available from the United Nations, New York, $0.50).

(2) Pawley, W. H., Possibilities of Increasing World Food Production, Basic Study No. 10, Freedom from Hunger Campaign, Food and Agriculture Organization of the United Nations, Rome, Italey, 1963. (Available from the United Nations, New York, $2.50).

(3) United States Department of Agriculture, The World Food Budget, 1970, Foreign Agricultural Economic Report No. 19, October 1964.

SECOND SESSION: Co-chairman: L. G. MacDowell, Florida Citrus Commission, presiding

H. H. Mottern, National Dairy Products Corporation, Chairman

NEW FOODS FROM SPUN VEGETABLE PROTEIN

by
W. W. Thulin
General Mills, Inc.
James Ford Bell Research Center
Minneapolis, Minnesota

Consumption of animal protein throughout the world varies almost directly with income (2). Man's apparent affinity for meat and other animal proteins is offset by their high price in terms of other goods and services. Only the rich have access to meat today, and there appears little likelihood of any significant change in this situation in the foreseeable future.

The high cost of meat results both from the inefficiency with which animals convert vegetable protein into muscle as well as the inefficiency of the labor and capital employed in its production and distribution. Table 1 contrasts the cost of producing representative animal and vegetable foods, beef and bread. Note the farm value of beef, a crude measure of the cost of vegetable raw materials, is

Table 1. --Costs of Manufacturing and Distributing Bread and Beef (Dollars per Pound Protein)

	Bread [1]	Beef [2]
Farm value	0.38	3.06
Transportation, handling and storage	0.02	0.38
Processing & retail margins	1.15	1.00
Retail price	1.55	4.18 [3]

1/ See reference (7).
2/ See reference (1).
3/ Net of by-product credits - not shown.

eight times that of bread. It costs as much to process and distribute beef in a semi-finished form as it does to convert wheat into a state ready for consumption. The consumer must pay over three times as much per pound of protein in raw beef as in bread. Breeders and geneticists continue to reduce the cost of feed per unit of meat, but there is no prospect of altering the basic economic cleavage between animal and vegetable foods.

While much remains to be learned of the origin of man's desire for meat, its nutritional excellence and its contribution of savor and textural variety doubtless play major roles in establishing its almost ubiquitous franchise. Protein isolation and synthetic fiber technology appear to offer a means to achieve with vegetable proteins textural heterogeneity and nutritional excellence heretofore associated only with meat. Because flavor, texture and appearance are all independent variables, the family of foods one can prepare by these techniques also provides a new measure of dietary variety.

In the complex, adaptable matrix attainable with fiber formulations, two or more nutritionally complementary vegetable proteins can be incorporated to overcome the nutritional disadvantages of any single vegetable protein. The complexities of fiber preparation, of course, are unnecessary for such balancing as has been demonstrated by the INCAP group (5). Savor excellence and variety are more difficult to obtain in vegetable protein foods because most of the better quality vegetable protein sources have characteristic flavors difficult to avoid or mask. These offending components can be removed during protein isolation, and measures can be taken to prevent their regeneration. However, the major contribution fiber technology has to make is textural complexity. Vegetable protein isolates, which in their natural state yield gruels or, at best, soft gels, can be converted into a series of interesting, texturally heterogeneous foods. Today I shall try to outline briefly how this new food genus is prepared, list its characteristics and discuss the role I and my colleagues expect it to play.

Manufacture

Several methods of preparing textured foods from spun vegetable protein have been described. One approach is depicted in Figure 1 (10). The protein contained in any of several vegetable sources is extracted with water and alkali and refined to yield a bland isolate of 95 to 98 percent purity. Proteins considerably less pure than this can be spun, but it appears necessary to achieve this degree of refinement in order that disagreeable flavor components present in the raw material will be removed. Such protein, in the form of a concentrated solution or spinning dope, is then extruded through dies or spinnerettes into a coagulating bath where fiber formation occurs. (See figure 2). The diameter of these filaments, shown after dehydration in figure 3 can be varied from 1 to 30 thousandths of an inch. By altering the composition of and treatment given the spinning dope, the configuration of the orifices in the spinnerettes, the composition of and conditions in the bath and the degree to which the fibers are stretched, their character can be varied from delicate, tender fibrils to coarse, tenacious strands.

While the fibrils play a critical role in these foods, they are only one of several essential components. The fibrils are intimately mixed with fat, flavoring, coloring, supplemental nutrients and stabilizers and bound together with a heat coagulable protein or other binding system. As demonstrated in figure 4, the fibrils may be either aligned or randomly oriented.

Each component introduces a degree of freedom in formulation. Hence, it is feasible to prepare a wide array of highly dissimilar foods. After fabrication, individual products can be sliced, ground or diced. The hors d'oeuvres served this noon illustrate some of the range of characteristics which are attainable.

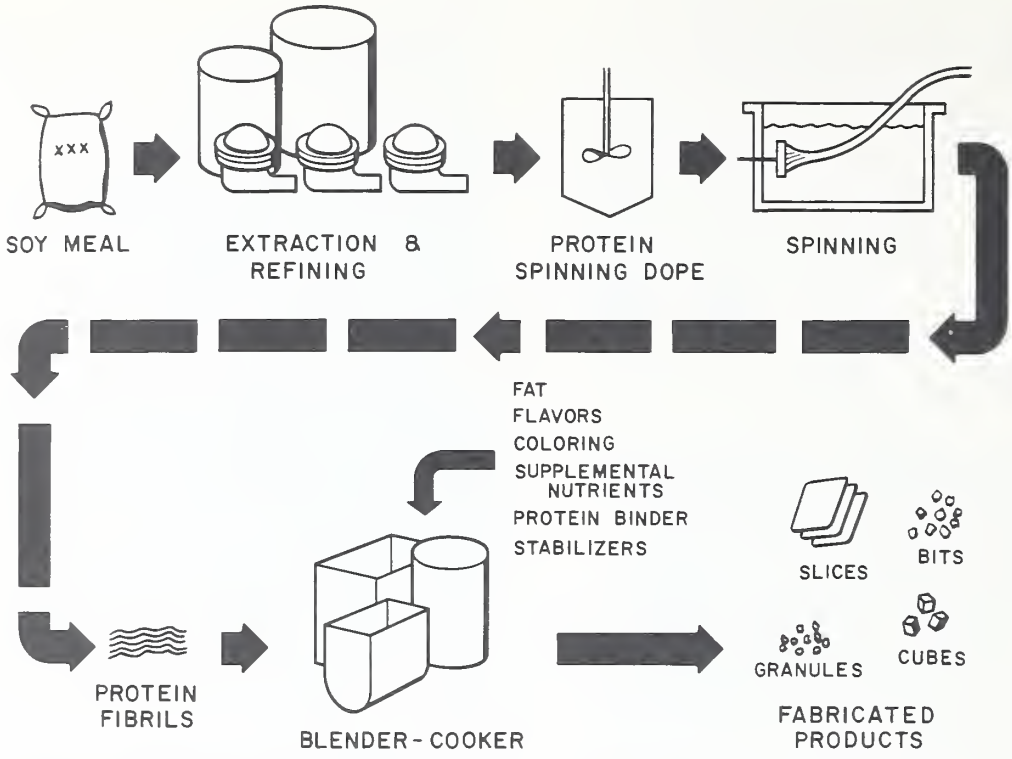

Figure 1.–PREPARATION OF TEXTURED FOODS FROM SPUN VEGETABLE PROTEIN.

Figure 2.–PILOT SPINNING UNIT, GENERAL MILLS, INC.

Figure 3.–FREEZE DRIED EDIBLE SOY PROTEIN FIBERS. Each tow comprises approximately 15,000 fibrils.

Composition

The composition of a typical produce is presented in figure 5. All data are given on a dry basis. In the ready-to-eat state, most of these products, like meat, comprise 60 to 70 percent water (3).

Fibrils account for only 30 to 60 percent of the total dry weight. While we have worked primarily with soy protein because of its fortunate combination of nutritional quality and economy, we and others have found many proteins can be spun including zein, casein, cottonseed, peanut, sunflower and safflower.

We are still dependent largely on egg albumin for bonding. Egg albumin makes a significant nutritional contribution, but it is costly and dependence on a single bonding agent limits the degree of textural control theoretically attainable. We are following with keen interest work on vegetable protein gels and look forward to supplementing or supplanting egg albumin with such materials.

Fat content can be varied from essentially zero to a practical upper limit of 50 percent of the dry weight. Limpid as well as higher melting fats of either animal or vegetable origin can be employed.

Many textureless nutrients can be incorporated in the fiber matrix to achieve nutritional balance. Other vegetable proteins or protein-rich materials, animal proteins such as lactalbumin, amino acids, minerals and vitamins can be introduced.

Flavor and color can be provided by natural or artificial systems or by combinations of both. For example, meat broth, meat fat and meat itself can be incorporated along with vegetable protein hydrolyzates, synthetic flavors and flavor enhancers. Similarly, fruit pulp and artificial fruit flavors and natural and artificial spices can be employed effectively in concert.

As indicated in figure 6, these spun protein foods typically contain more protein and less fat than most meats, although the

Figure 4.--ILLUSTRATIVE PRODUCTS PREPARED FROM SPUN PROTEIN. Note the linear orientation of protein fibers in product at left and random orientation in product at right.

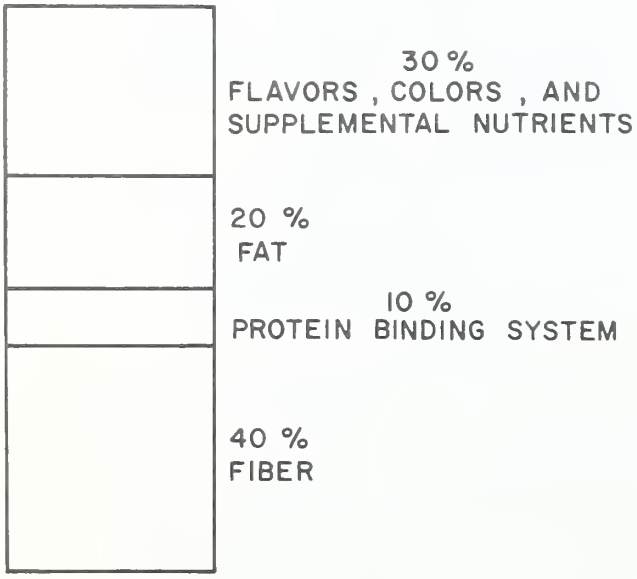

Figure 5.--Composition of typical products.

concentration of both constituents can be varied widely. They also contain lower levels of carbohydrate, introduced in the flavor-color and supplemental nutrient systems.

Nutrition

Combinations of soy protein and egg albumin, as one would expect, yield foods of high protein quality. A portion of the sulfur amino acids found in soy meal is lost in the extraction and purification process (9). Consequently, as has been reported elsewhere (4, 8, 6), the protein efficiency ratio (P. E. R.) of isolated soy protein is significantly lower than that of soy meal or casein.

We have found that P. E. R. of spun protein extracted from high solubility soy meal is approximately 1. 6, (weanling Sprague Dawley rats fed 10% protein diet for 28 days). However, the protein efficiency of foods fabricated from these fibrils approaches that of casein without specific amino acids supplementation. The broad range of ingredients inherent in almost all of the formulations with which we have worked affords the necessary complementation. Higher protein efficiency levels can be achieved by incorporating small quantities of selected amino acids and/or proteins.

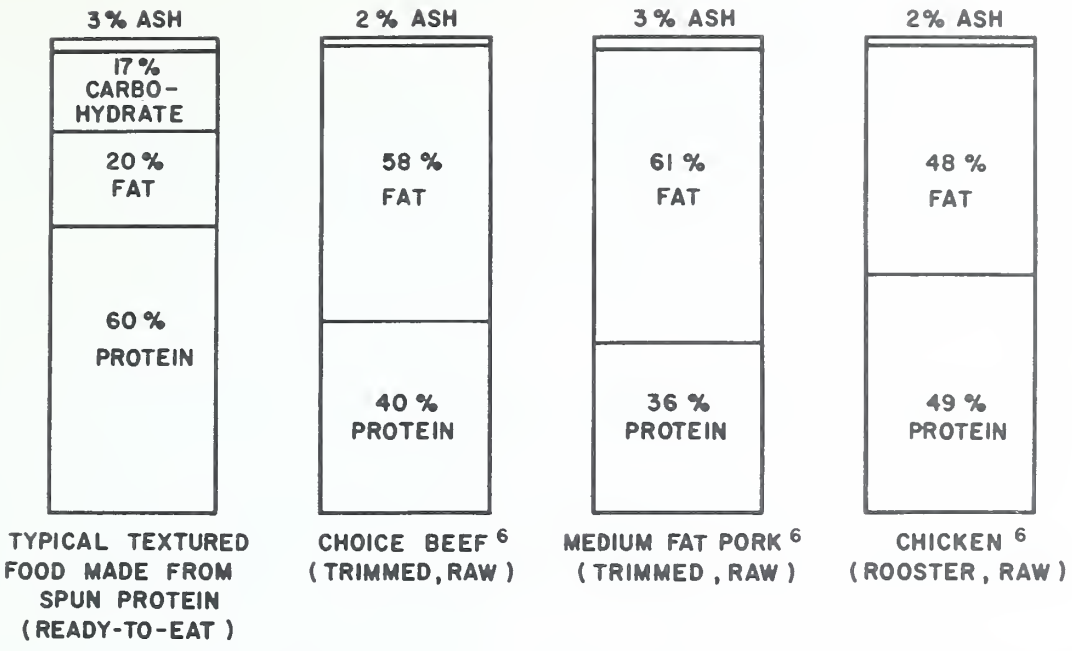

Figure 6.–Composition of spun protein foods.

Economics

The efficiency with which animals convert vegetable to meat protein is usually assumed to be of the order of 10 percent. In contrast, the protein yield of the process I have described is at least 85 percent.

This technology is complex, and a substantial investment is required to produce these foods in commercial quantities. Nonetheless, the economic advantages inherent in continuous processing and the profound improvement in efficiency with which interesting, nutritionally excellent protein foods can be produced by these techniques offer much economic promise.

We estimate, on the basis of existing technology, that attractive ready-to-eat protein foods can be offered in commercial quantities at the manufacturing level for approximately one-half the cost of the corresponding cooked meat. Since this technology is still in its infancy, increasing technological sophistication and increasing output are expected to increase this disparity.

Applications

Reports beginning to appear in the press indicate concern on the part of livestock interests about competition from these new foods. Fortunately or unfortunately, depending on one's point of view, the domestic animal has little to fear. We expect spun protein foods analogous to meat as well as species providing novel characteristics to find application; however, both appear likely to assume a role complementary to meat, not directly competitive. In fact, meat probably will be incorporated in some of the meat analogs.

Most meat is consumed as such, in slices, patties or large pieces. This market is largely immune to competition. The probability of duplicating a system as complex and distinctive as a large piece of meat is small. Even if this were not the case, consumers will change their eating habits only if given a compelling reason to do so. The economic advantages we have discussed might be thought to provide this incentive as is the case with margarine. However, the two situations are quite different. Consumers are aware of the true economic relationship between butter and margarine because they purchase both in a form ready for consumption. Few consumers, however, are fully aware of the actual cost of cooked meat because they purchase it raw, usually with an appreciable quantity of bone, and rarely measure the actual yield of cooked lean meat. Foods prepared from spun protein are cooked during manufacture. Therefore, these ready-to-consume products would necessarily compete in the consumer's mind against raw meat

meat which is only 30 to 80 percent of the cost of its cooked counterpart.

Furthermore, in the absence of a publicly financed educational effort, the spun protein foods themselves must bear the sizeable cost of educating consumers, through advertising, to the existence of the new genus. Hence, the economic advantage enjoyed by these new foods at manufacturing level would be significantly eroded by the time they were presented, as such, to the consumer.

Consequently, spun protein foods will probably be limited in traditional cookery to use in three areas: (1) in formulated specialties, either alone or in combination with meat, (2) in foods with unique nutritional characteristics and (3) in situations where meat consumption is restricted for religious or cultural reasons. In formulated foods such as casseroles, the uniform quality, economy and freedom from gristle and striffen afforded by spun protein meat analogs are welcomed by food processors and will result in higher quality products. Because their composition can be varied widely and precisely controlled, spun protein foods are useful in well-defined diets and as vehicles for dietary supplementation of vitamins, minerals and other nutrients. Spun protein meat analogs are already finding application in this country among groups with religion-oriented dietary restrictions. Possibly greater potential lies in the more affluent segments of Eastern vegetarian cultures where the textural variety these foods yield will be enjoyed without any meat connotation.

In the West, meat analogs prepared from spun protein appear most useful in foods where meat cannot be used for technical reasons and in new foods where no definition exists in the consumer's mind. For example, through the use of stable fats and/or fat stabilizing systems, it is practical to prepare dehydrated meat-like products which, unlike dehydrated meat, do not develop rancidity or undergo other forms of deterioration when exposed to air at room temperature. These materials are applicable as condiments for use in the home, in quick bread and casserole mixes, dips and pourable salad dressings where meat is too unstable for protracted use. They are also useful to manufacturers, such as bakers and vegetable processors, who would like to introduce into their products the organoleptic and nutritional qualities of meat but do not have the facilities to handle it.

Hydrated and dehydrated spun protein foods can be given any configuration desire, and their organoleptic characteristics can be tailored to meet the needs of specific food formulations. Thus, they are well suited to new products such as snacks, spreads, and salads.

Finally, spun protein technology makes it feasible to give a new measure of dietary variety to the general consumer. Because it is possible to separate the desirable textural qualities of meat from its associated flavors, it is practical to supply new flavo-textural combinations. Cheese, vegetable and fruit-flavored products can be prepared as can textured foods incorporating some of the rich, fermentation-derived flavors of the Orient.

Man is notoriously conservative with respect to his diet. Even we in the United States who give less heed to tradition than perhaps any other people, like our foods the "old fashioned way Grandmother used to make." Consequently, one cannot look for this series of foods or any other to take the world by storm. Nonetheless, this technology's capacity to prepare varied, economical protein foods in a world where economy and high quality protein are almost antithetical may allow it to make a significant contribution to our well being.

References

(1) "Beef Marketing Margins and Costs," Miscellaneous Publication No. 710, U. S. Department of Agriculture, 1956.

(2) Brown, L. R., "Man, Land & Food," Foreign Agricultural Economic Report, No. 11, U. S. Department of Agriculture, 1963.

(3) "Composition of Foods," Agricultural Handbook No. 8, U. S. Department of Agriculture, 1963.

(4) Hackler, L. R., Hand, D. E., Steinkraus, K. H., and van Buren, J. P., J. Nutrition 80, 205-210 (1963).

(5) INCAP, Incaparina, Guatemala, 1962.

(6) Longenecker, J.B., Martin, W.H., and Sarett, H.P., Agricultural and Food Chemistry 12, (5): 411-412 (1964).

(7) "Marketing Margins for White Bread," Miscellaneous Publication No. 712, U.S. Department of Agriculture, 1962.

(8) Rackis, J.J., "Protein Efficiency Studies on Soybean Meal and Its Fraction," p. 100-108, Proceedings of Conference on Soybean Products for Protein in Human Foods, September 13-15, 1961.

(9) Rackis, J.J., Anderson, R.L., Sasame, H.A., Smith, A.K., and van Etten, C.H., Agricultural and Food Chemistry 9, (5): 409-412 (1961).

(10) Weiler, J.E., U.S. Patent 2,682,446 (October 23, 1947).

BREEDING VEGETABLES AND FRUIT FOR PROCESSING

by
F. S. Jamison
Institute of Food and Agricultural Science
University of Florida
Gainesville, Florida

When invited to talk on the subject of fruit and vegetable breeding for processing, I indicated that I knew more about vegetables than fruit, and if I talked emphasis would be on vegetables. Even this is somewhat of a challenge to one who has worked in the State where the primary effort has been in producing vegetables for the fresh market.

In Florida there is a continuing increase in acreage of crops for processing, much of it the direct result of plant breeding research, even though this research has been conducted in many other areas of the United States.

There are three important areas a breeder must consider if he is successful in developing crops for processing.

First is developing a variety of strain that can be grown economically over rather a wide geographical area. This is in itself a challenging task. The strain or variety must possess superior yielding potentials under the prevailing climatic conditions in which it is to be grown, and, at the same time, it must possess resistance to important prevailing diseases or physiological disorders of older varieties. To properly assess breeding materials it would appear almost mandatory for the breeder to have rather complete knowledge of the performance of presently available varieties. This becomes increasingly difficult as variety evaluation or testing becomes increasingly unpopular with Experiment Station personnel.

In addition to performance as a crop, propagating material, whether it be seeds or plants, must be obtainable, of high quality and reasonable in cost. Many varieties of beans have performed well only to be discarded by breeders because of difficulties in securing seed without split seed coats or other similar seed defects.

The yielding ability of a variety is so closely inter-related to culture practices, such as kind and quantity of fertilizers, spacing or plant population, and other such practices as to make it exceedingly difficult for the plant breeder to fully evaluate a variety's performance on small breeding plots, but rather the more promising of several lines or strains developed must be tested under a variety of cultural conditions to determine whether they equal or exceed varieties they might replace.

Breeders know that usually large plants produce a larger average yield per plant than small or semi-dwarf plants, but this does not necessarily mean increased acre yields. If smaller plants can be spaced closer together and thus increase the plant population per acre then the acre yield of smaller plants may equal or exceed that of larger plants. This is true with a number of vegetables. While yield is an important characteristic, of equal importance is the resistance to specific disease or physiological disorders.

In Florida during the past several years the acreage of spinach for processing has increased quite rapidly. This has been due in large part to the development of hybrid spinach varieties that under the climatic conditions prevailing in Central Florida are resistant to mildew. The resistance to mildew plus uniformity of maturity has resulted in excellent yields and a rapid increase in acreage which is mechanically harvested.

Probably no single factor has been of any more importance in maintaining the growing of tomatoes for processing in the Middle Atlantic States than has the development of varieties resistant to fruit cracking. This has been historically a severe limitation in tomato growing in the more humid areas of the country. As fruit approached the full ripe stage they developed radial cracks around the stem allowing for infection with molds or other diseases or insects.

Processing companies through the years have found strains of tomatoes resistant to cracking and have incorporated this resistance into a high yielding quality variety.

This has allowed these areas to continue to produce tomatoes for processing in competition with the more arid areas of the west. But even here breeding cannot stop for the arid areas have now been most successful in development of semi-dwarf tomatoes which mature a large percentage of their fruit within a relatively short period of time and are easily removed from the vine. These characters have permitted the introduction of successful mechanical harvesters into tomato fields, greatly reducing the cost of harvesting.

Unquestionably, hybrid vegetables will increase in importance. Most of the sweet corn, onions, spinach and certain other crops are now grown almost entirely from hybrid seed. Hybrids have certain excellent characters, one being increased acre yield and another uniformity of maturity. It is necessary that hybrids be evaluated in terms of resistance to certain difficulties that nonhybrid varieties may possess. Hybrid tomatoes have proven quite successful in many areas but thus far we do not have hybrid varieties resistant to fusarium wilt or other diseases. The increased use of hybrid seed has increased the complexity of the breeder's job. He no longer can anticipate introducing a variety but rather must develop inbreds that will carry certain definite genetic characters.

The second thing of importance for the breeder is developing a variety that is suitable for efficient harvesting and handling. This may mean, one, that it is adapted for mechanical harvesting or is simply easily harvested.

Certain plants have fruit which can be removed from the plant with a minimum amount of physical effort while other plants require considerable force to separate the fruit from the plant. With certain crops, such as beans and tomatoes, the peduncle may stay attached to the fruit when the fruit is removed from the plant or it may be detached as the fruit is removed. This may be either a desirable or undesirable character depending on how the material is to be used.

In discussing hybrids we mentioned uniformity of plants and this can be best illustrated by cabbage varieties. Recent work with machines for harvesting cabbage has shown that in a once-over harvesting operation of nonhybrid varieties about sixty percent of the plants harvested were ready for harvest. Whereas with hybrid varieties this percentage ran above ninety percent. Hybrid sweet corn varieties shows the remarkable uniformity that can be achieved.

Hybrid corn grown for fresh market in Florida is harvested by men who move through the fields in front or in back of a movable belt on which the corn is placed after it is pulled from the plant. The corn is then carried by this belt to sorting and packing bins where it is packed in crates ready for market. Research personnel have indicated that more than ninety-five percent of the available crop is harvested by a single harvest.

Dr. Lorz, at the University of Florida, has found characters in Southern peas which he has used in his breeding program, we believe, make these edible cowpea varieties much more adaptable for mechanical harvesting or even for hand picking. One of the characters he has used is to place pods well above the foliage of the plant. This may be an advantage for certain types or kinds of mechanical harvesters and for hand harvesting.

However, he has also developed varieties where the pods are quite concentrated in maturity dates and where the yield of pods to the vegetative growth of the plants is quite high so that the usual type of mechanical bush bean harvester can be used successfully.

One of the difficulties with Southern peas has been in shelling the peas after they are removed from the plant. Even here it is possible that once the complete cataloguing of available plant characters is developed we may find assistance.

Dr. Lorz has strains in his breeding plots where the pod splits open its full length before the peas are even mature enough for harvesting. Whether this trait can be controlled sufficiently to use in producing plants where the pods will be easily opened remains to be seen.

One interesting development has been the attempt to harvest pickles mechanically. First efforts at harvesting pickles from the normal viney cucumber plant were rather unsuccessful, but plant breeders have found a plant type which may increase the possibilities for machine harvesting. This is a miniature plant about 12-15 inches tall and at this stage has a number of pickles present on it. These plants, of course, can be grown quite close together so that the total acre yield at a single harvest would not be too greatly different from that secured at a number of harvests from normal cucumber plants spaced at the usual distances.

The third hurdle that the plant breeder has in developing varieties for processing is whether or not his crop is adaptable for processing. Is it easily cleaned and prepared? Does it bruise easily? Do bruises affect the processing, and, of course, what is the quality of the product after processing?

Breeders have touched only slightly the potentials of this phase of the breeding program. The breeder is aware that color, flavor, aroma, texture and other characters are of importance in determining the market quality of the processed product. He knows he has a host of genetic characters available that have not been evaluated fully as to how they affect changes in these various categories. Nor have the desirable characteristics of processed products remained very constant.

The consumer has a way of changing her mind and making a choice which often appears to many in no way associated with any logical decision. One of the big selling items in the last few years in frozen food has been a multicolored seed-coated lima bean. A few years ago we would have thought this item next to impossible to sell in any large volume as frozen products.

The Romano, or Italian bean, is another item that has had a big play for the past few seasons yet to many professional horticulturists it is not a particularly high quality bean. Chinese peas sounds like a new and intriguing vegetable until we find it an edible podded English pea grown in a limited manner for many years in this country and rather extensively in Scandinavian countries.

In many instances the breeder is unable to judge the final quality of his product and must depend on food technologists or others for this evaluation. Quite often a slight change in processing technique may make a new variety acceptable or at other times a breeder must again screen his material to find the illusive but desirable characters required.

Bean processors have considered the variety Blue Lake, a pole variety, as having deluxe quality for canning. High production and harvesting costs of pole beans has encouraged the attempt to produce a bush type plant producing pods with the shape, size, and other characteristics of the pole variety. They have been reasonably successful in doing so except perhaps for transmitting the unusual flavor characteristic of the Blue Lake to suitable bush type plants producing a concentrated yield of pods. Even here until objective tests for this illusive flavor character is developed breeders must depend either on their own or other individual's judgment for evaluating new lines for flavor.

Processing eggplants was virtually unknown before the last World War. Since then the crop has become a processing item of some importance. What are the characteristics desired in an eggplant to be used in making frozen French fried eggplant? Since Florida produces the major portion of this crop we have had complaints directed to us about 1) a bitter taste, and 2) seeds turning dark. It is questionable whether either of

these characteristics are particularly important if the present varieties are grown and handled properly. Both of these characters can be induced by exposure of fruit to an unfavorable post-harvest environment.

On the other hand, if browning during preparation is of importance there are varieties that do not discolor on cutting and the lack of this character does not, from superficial examination, appear to affect flavor or other apparently desirable attributes. This character is not limited to eggplants but is in many other vegetables and fruits.

In a breeding project with eggplants a few years ago, we noted tremendous variations in the specific gravity of fruit from various lines. Whether a low or high specific gravity is more or less desirable for processing is unknown. But if there is a preference, it could be easily incorporated into most any variety.

In a search of literature an abundance of literature can be found on fruit evaluation for processing quality. Fruit breeding, particularly with tree fruits, is a long time operation. Thus, while a great deal of research has been done in testing existing varieties for various products and processes, there apparently has been a limited amount in developing varieties specifically for processing.

As additional product specifications become available to horticulturists, breeding will probably be accelerated even in these long time crops. At present there is considerable breeding with peaches, grapes, cherries, and certain other fruits primarily to eliminate production faults of presently available varieties. Thus, with both vegetables and fruits, the breeder can progress most rapidly when he has specifications of what is desired in a variety.

There is, however, no assurance that these specifications will remain constant. Indeed we know these specifications constantly change. The experienced plant breeder knows the limitations and potential of this breeding material. He is expert at manipulating genes and in making numerous combinations or recombinations of available characters; but if the genes are not present for the particular desired character reshuffling will not result in progress. In this case, progress can only be made if additional material having the desirable character can be located. A good example is tomatoes. More than thirty years ago, Dr. Pritchard developed a variety Marglobe. This variety had some resistance to fusarium wilt but in no sense possessed immunity. It was not until material from South America was brought into the country and found to possess almost complete immunity to fusarium wilt were plant breeders able to put this character with the other desirable characters and produce a variety immune to fusarium wilt.

Plant breeding can make a very definite contribution to the processing industry. Before a superior job can be done the processor's needs must be well established and the breeder must have help in evaluating his material both from the standpoint of production and suitability for use as processing material. Certainly, any improvements made in our various crops by breeding must produce the crop economically, must produce a crop that can be easily harvested and prepared for processing and must result in a product acceptable to the consumer.

PURE CULTURE FERMENTATION OF BRINED CUCUMBERS

[Summary[1/]]

by
J. L. Etchells, R. N. Costilow, T. E. Anderson
and T. A. Bell
U. S. Food Fermentation Laboratory
Southern Utilization Research and Development Division
Raleigh, North Carolina

(Presented by J. L. Etchells)

The relative abilities of Pediococcus cerevisiae, Lactobacillus plantarum, L. brevis, and several other species of lactic acid bacteria to grow and produce acid in brined cucumbers were evaluated in pure culture fermentations. Such fermentations were made possible by the use of two techniques, gamma radiation (0.83 to 1.00 Mrad) and hot-water blanching (66° to 80° C. for 5 min.), designed first to rid the cucumbers of naturally occurring, interfering, and competitive microbial groups prior to brining, followed by inoculation with the desired lactic acid bacteria. Of the nine species tested, strains of the three common to cucumber fermentations, P. cerevisae, L. plantarum and L. brevis, grew to the highest populations, and produced the highest levels of brine acidity and the lowest pH values in fermentations at 5.4 to 5.6 percent NaCl by weight; also, their sequence of active development in fermentations, with the use of a three-species mixture for inoculation, was in the species order just named. This sequence of occurrence was similar to that estimated by others for natural fermentations. The rates of growth and acid product in fermentations with a mixture of P. cerevisiae, L. plantarum, and L. brevis increased as the incubation temperature was increased from 21° to 27° to 32° C.; however, the maximal populations and acidities attained were essentially the same for fermentations at each temperature. Further, these same three species were found to be the most salt tolerant of those tested; their upper limit for appreciable growth and measurable acid production was about 8 percent salt, whereas thermophilic species such as L. thermophilus, L. lactis, L. helveticus, L. fermenti, and L. delbrueckii exhibited a much lower salt tolerance, ranging from about 2.5 to 4.0 percent. However, certain strains of L. delbrueckii grew very rapidly in cucumbers brined at 2.5 to 3.0 percent salt, and produced sufficient acid in about 30 hr. at 48° C. to reduce the brine pH from above 7.0 to below 4.0. An inexpensive, pure culture fermentor which was suitable for gamma radiation, resistant to salt and acid, and which permitted repeated aseptic sampling of the fermenting brine, is illustrated and the specifications are given.

1/ The paper presented was essentially that appearing in Applied Microbiology 12, 523–535 (1964).

DEVELOPMENT OF PEACH PRODUCTS[1/]

by
J. G. Woodroof, E. K. Heaton, T. S. Boggess, Jr., and K. C. Li
Georgia Experiment Station
Experiment, Georgia

(Presented by J. G. Woodroof)

Peaches are grown in the Southeast primarily for the fresh market and secondarily for processing. Processing is largely restricted to canning, with a few being pickled,

1/This is a condensation of information presented in eight quarterly progress reports on a study of "Development of Peach Products," being conducted jointly between the Department of Food Science, Georgia Experiment Station; the Southern Utilization Research and Development Division, Agricultural Research Service, and Office of Rural Area Development, United States Department of Agriculture; and supported by the Area Redevelopment Administration, United States Department of Commerce, Washington, D.C.

frozen, or made into preserves. A good quantity of the low quality fruit goes into wine or brandy.

The per capita consumption of fresh peaches has been declining for about two decades. This has resulted in retrenchment of the industry in many counties, especially in the Piedmont area. Decline in production has happened in the light of the introduction of improved varieties, more economical means of culture, and more efficient means of controlling insects and disease.

Growing peaches in suitable areas of the Southeast has been a stable agricultural enterprise for more than a half century. It has been important in not only providing a substantial income, but a means of employment for many rural and suburban people. Even a slight decline in production is immediately reflected in the labor supply.

It is apparent that recovery or even maintenance of the peach industry in the Southeast lies in the area of expanding processing and marketing, as well as in production. Among the problems to be solved include: (a) making peaches available in a more convenient form without the necessity of peeling or pitting by the consumer; (b) supplying peaches in portion-control form to even out servings without leftovers; (c) making peaches available in ready-to-serve form by one not skilled in food preparations, without the need of cooking, sweetening, or other treatments; (d) providing peaches to the consumer on a more nearly year-round basis so as to extend the geographical area and time of consumption; and (e) providing an outlet other than the fresh market for many varieties with quite different characteristics that ripen successively, over a period of four months. Of more than a dozen promising peach products, two are discussed in this report. The results are from three crop seasons.

Puree-Type Peach Drink

During the past two decades, consumption of fruit juices has increased rapidly. This is in the form of juices, nectars, fruit drinks, fruit ades and breakfast drinks. Soft-ripe peaches have qualities especially desirable for these products. Especially valuable are the color, flavor, and viscosity of peach juice.

The objectives are (a) to more completely utilize the peach crop, especially that portion remaining after the choice fruit is removed for shipping fresh. It is estimated that 75 percent of some early varieties and 25 percent of the Southeastern peach crop falls in this grade. (b) to build in more value and thereby stabilize the production and labor supply in the peach industry. (c) to devise a means of producing and preserving a product from the edible portion of peaches of all varieties. This includes both clingstone and freestone varieties of other widely different characteristics and ripening seasons.

Puree for juice was prepared from more than two dozen varieties, including those that ripened early, midseason and late; also included were clingstone, semicling, and freestone varieties, as well as some of poor, medium, and high flavor. In general, early varieties were small clingstone, with a high percentage of split seed, high in moisture and acid, ripened unevenly and bruised easily, lacked yellow color and firmness, and were generally poor for eating fresh and unsuitable for canning.

Approximately 80,000 pounds of puree were prepared for evaluation, of which 2,800 pounds was for ice cream from selected fruit; a total of 52,658 pounds was for beverages, of which 21,868 pounds was prepared from clingstone peaches; and 28,986 pounds from freestone fruit. Of the above, 27,792 pounds were made from B-grade fruit from packing houses, and 23,062 pounds were made from assorted, tree-ripe, orchard run fruit. Additional quantities were used for topping, salads, sauces, and bakery items. Some of it was reprocessed by drum-drying and making into jellies and jams.

Summary of Results

1. Peeling peaches before pureeing was necessary. Puree prepared from Marcus, Dixired, Redhaven and Keystone varieties showed that peeling improved the appearance, aroma, color, and flavor, but did not appreciably affect the soluble solids, pH, or viscosity of the finished product. Peeling reduced the yield about 15 percent, removed part of the "peach-leafy" flavor, as well as sulfur and other spray residues. Immersion peeling after pitting reduced the yield 8 percent, removed most of the red color compon-

ent, yielding a product with a pale yellow color, mild peach aroma and flavor. This product was described as watery, lacking body and flavor after standardizing.

2. Red color was undesirable. A large amount of red pigment at the seed, or near the surface of ripe peaches was undesirable because it frequently turned various shades of gray, blue or purple during processing and preservation. This discoloration was apparently due to oxidation, enzymes, metals or acidity.

The color and consistency of peach puree was improved by "finishing" it through a 0.033 stainless steel screen, to remove fibrous material.

It was found that with many varieties of peaches the use of 0.14 percent ascorbic acid or a mixture of four parts citric acid and one part ascorbic (0.37 percent) did not completely prevent browning and development of oxidized flavor. The addition of 22.5 ppm sulfur dioxide brightened the color, improved the flavor, and protected both the color and flavor of peach puree and peach juice.

3. Heating peaches before pureeing was advantageous. It was found that heating the peeled fruit in the absence of air, to 140° F. for two minutes before pureeing, softened the fruit, prevented darkening, and decreased cloud in the finished product. While the flavor was changed, the product was not appreciably degraded.

Results of evaluations of frozen puree of fully ripe, peeled Dixired, Sullivan Elberta, and Elberta varieties of peaches showed: (a) the addition of ascorbic acid (0.14 percent) was the most effective way of preserving the natural appearance, aroma, color, and flavor. It increased the acidity, and lowered the viscosity slightly. (b) The addition of sugar to 17° Brix improved the aroma and flavor, decreased the acidity, viscosity and separation. (c) De-airing prevented separation of juice and pulp and improved the appearance, but failed to protect the color; it decreased the viscosity, acidity, aroma and flavor. (d) Bubbling nitrogen through the puree had little effect on quality except the development of an "overripe" flavor, and a reduction in the amount of separation and viscosity.

4. Concentrating the puree more than twofold was impractical. This was due to the high viscosity of the puree and the loss of volatile aromas, even when vacuum was used.

Concentrating the puree removed desirable aroma and flavor, and left a more astringent flavor. Straining or removal of cell fragments also removed desirable flavor. Consequently, juice that had been strained or concentrated had less bouquet and more astringency than single-strength puree or juice.

Results from concentrating juice from Dixired, Sullivan Elberta and Elberta varieties of peaches twofold and threefold showed that the three varieties responded differently as follows: (a) Concentrating reduced the volatile aromas, flavors, viscosity, and acidity; imparted a slightly grey color, and prevented separation in the Dixired variety. The reconstituted and standardized puree made a high quality drink as shown by results of a three- and ten-member sensory panel. (b) Concentrating reduced the volatile aromas and flavors, and improved the color slightly for the Sullivan Elberta variety. The reconstituted and standardized puree made a highly acceptable drink. (c) For the Elberta variety concentrating removed volatile aromas and flavors, reduced the sheen, and increased the viscosity. It also developed aroma and flavor of dried peaches.

The speed at which peaches were pureed affected the quality of the single-strength and standardized product. Puree made at a paddle speed of 1,000 rpm was satisfactory, but that made at a higher speed had progressively larger amounts of air whipped into it. This entrapped air caused a pale color and an oxidized aroma and flavor in the single-strength and standardized products.

5. Stabilized puree was good for drinks. A highly acceptable peach puree was prepared from blends of varieties, and the use of additives to produce a product (a) with soluble solids in a range from 13 to 18 percent; (b) with total acidity of 0.52 percent; (c) soluble solids/titratable acidity ratio of 30 to 38; and (d) viscosity from 100 to 200 cps.

The addition of sufficient sugar to raise the total solids from a normal of about 11

percent to 13 percent, increased the sheen, tended to mask the bouquet and reduced volatilization of flavors during further processing.

It was found that ascorbic acid was superior to blanching or vacuum de-airing for preserving the natural appearance, aroma, color, texture and flavor of peach puree. After standardizing into a drink the de-aired sample was rated highest, being considered normal on all qualities. The ascorbic acid-treated sample rated second highest, being normal except for slightly dull color. The blanched sample which was rated third lacked peach aroma and flavor.

Peach puree showed possibilities of being successfully blended with orange juice at the rate of about 15 percent. Encouraging results were also obtained by blending peach puree with pineapple juice, ginger ale, and lemon juice.

Consumer acceptance from about 13,000 servings of peach juice at cafeterias, restaurants, and luncheons, showed this product to be preferred to six other fruit juices, except orange.

6. Viscosity of puree was reduced by pectinase. The viscosity of peach puree could be readily reduced from syrup-like to watery consistency by the use of lg./8 lbs. pectinase enzymes (Klerzyme 200, Klerzyme B 612 or Pectinol 1M) for one hour at 80°F. The juice could then be filtered, clarified, centrifuged and concentrated sixfold. This juice is the base for the manufacture of concentrated peach juice. The concentrate is used commercially for wine and brandy and is being tested as a flavoring for ice cream, jelly, jams and bakery products.

The pectinase enzymes at the concentrations studied, brightened the appearance, prevented separation, slightly lowered the flavor, and reduced the viscosity, but did not influence the pH, total acidity or soluble solids. The enzyme TJ No. 611 (Proteinase) had no appreciable effect on the peach puree except for a slight dulling of the appearance, and the development of an objectionable off aroma and flavor, which was described as "sulfury," "metallic," "old peach."

Steps in Preparation

1. Select ripe, worm-free peaches of any variety that are practically free of rot, "leakers," and off flavors.

2. Grade for soft ripeness and freedom from defects. Hold firm-ripe fruit until soft, discarding that which is green or has undesirable odor.

3. Peel by immersing in 5 percent lye at 210°F. for 30 seconds.

4. Remove loose peel in rotary washer using very fine sprays.

5. Brush lightly with soft nylon brushes and trim with knife to remove bruised or rotten spots.

6. Heat whole fruit in continuous thermascrew for 2 minutes, at 200°F. to aid in pulping, prevent oxidation and stabilize cloud.

7. Run through pulper with 1/4 in. perforated screen to remove soft flesh from seed and unripe portions.

8. Run through finisher with 0.033 or 0.024 in. perforated screen to remove fiber and reduce remainder to liquid.

9. Accumulate in tank, add .14 percent ascorbic acid by weight and mix prior to pasteurizing.

10. Quick-pasteurize at 190° F. and cool quickly.

11. Fill aseptically into sterile 55-gallon drums, or chill and fill into 55-gallon drums for refrigerated storage, or fill hot into No. 10 cans.

To prepare drink: 1. Blend puree of different varieties and adjust to 13-18 percent soluble solids, 0.52 percent total acids, 30/38 soluble solids/acid ratio, and 100-200 cps viscosity.

2. Pack into consumer size cans or bottles, pasteurize at 190°F., cool and store.

Refrigerated Fresh Sliced Peaches

A trend toward the use of refrigerated prepared fresh fruits is increasing. This method of marketing citrus fruits, apples, pineapples, and cherries has been quite successful. Fresh peach slices were marketed first in the Southeast about three years ago. Four factors add interest to the project. They are: increasing labor costs, lack of suitable equipment for peeling and slicing peaches in hotels and restaurants, built-in

convenience of the item, and ease of controlling the number of servings in public eating places.

Problems to be solved include (a) selection of varieties with suitable color, flavor, texture, and nonbrowning characteristics, as well as those with successive ripening seasons; (b) selection of fruit of suitable size and degree of ripeness, and without objectionable defects; (c) procedure for peeling, pitting, slicing, packaging and refrigerating to retain fresh qualities; (d) determination of desired sweeteners, antioxidants, mold inhibitors or other preservatives for the product; and (e) distribution of product without loss of quality.

Summary of Results

1. Peaches for refrigerated fresh slices should be of best quality. They should be freestone, table ripe, medium to large, and deep yellow, with minimum of red color. They should also be of desirable texture, aroma and flavor, and resistant to browning.

2. Slices should be prepared rapidly and chilled quickly. Preparation consists of lye-peeling, deseeding, slicing, packing in containers with suitable medium and refrigerating immediately. Eighteen combinations of antioxidants and microbial inhibitors, and seven syrup concentrations were evaluated.

3. Glass containers were preferred. Tests with peach slices packed in transparent plastic bags and several sizes of glass containers showed quart glass jars to be preferred. This was because of the ease of displaying in stores, handling by purchasers, and serving in homes.

4. Optimum syrup concentration varied with the variety and degree of ripeness. Syrup functions to cover the slices and protect them from oxidation and browning, to sweeten the product, and to provide a medium in which the slices would neither swell nor shrink. The requirements of some varieties, and degrees of ripeness, is for a syrup with 20 percent soluble solids, while for others it is 25 percent. Below this range the product lacked sweetness, and syrups with more than 30 percent soluble solids causes the slices to shrink and float.

5. Corn syrup or dextrose may be used to replace sucrose as sweeteners. When regular corn syrup or dextrose were used to replace sucrose syrup, they were rated in the following order of preference:

100 percent corn syrup	40° Brix
100 percent sucrose syrup	30° Brix
66-2/3 percent sucrose and 33-1/3 percent dextrose	40° Brix
33-1/3 percent sucrose and 66-2/3 percent dextrose	40° Brix
50 percent sucrose and 50 percent corn syrup	40° Brix
50 percent sucrose and 50 percent dextrose	30° Brix
66-2/3 percent sucrose and 33-1/3 percent corn syrup	30° Brix
33-1/3 percent sucrose and 66-2/3 percent corn syrup	30° Brix
100 percent dextrose	30° Brix

Varieties responded dissimilarly to corn syrup and dextrose replacements. The Redglobe, for example, was decidedly degraded by the use of dextrose, variety B-53625 was degraded slightly by corn syrup; while Loring was not appreciably affected.

6. Benzoate and sorbate are good preservatives. In an attempt to find a single preservative or a combination of two or more preservatives that would extend the shelf-life beyond that where no preservative was used, four chemicals were used alone or in combinations. Five varieties, four horticultural selections, and a blend of varieties were used. It was found that: (a) different varieties and selections responded differently to the various preservative treatments; (b) combinations of sodium benzoate and potassium sorbate were more effective than diethylpyrocarbonate, sodium metabisulfite or combinations of these with benzoate and sorbate; (c) a mixture of equal parts by weight of sodium benzoate and potassium sorbate, used at the rate of 0.033 percent was most satisfactory; and (d) diethylpyrocarbonate alone and in combinations with benzoate and/or sorbate was probably the poorest preservative. All of the preservatives used at concentrations of 0.05 percent or above imparted objectionable flavors.

7. Artificial sweeteners may be used. Experiments were run in which 50 and 75 percent of sucrose were replaced by calcium cyclamate in syrups to equal a sweetness of 40 percent sucrose. Also, 90 percent of the sweetness in syrup 45, 50, 55, and 60 percent soluble solids equivalent was supplied

by calcium cyclamate. Results showed that (a) when calcium cyclamate was used to replace 90 percent of the sucrose in 50, 55, and 60 percent soluble solids equivalent syrups, the product was too sweet; (b) the sample in which 50 percent of the sucrose was replaced by cyclamate was rated highest; (c) the samples where 75 percent of the sucrose was replaced with cyclamate were rated poorest.

8. Use of vacuum to induce syrup penetration degrades the product. When the slices were covered with syrup and subjected to 25 inches vacuum or above, and released immediately, the product became waterlogged and translucent; and it lost aroma and no longer appeared fresh. However, the texture and flavor were excellent.

9. Pasteurizing destroys freshness of sliced peaches. While pasteurizing the slices after being packed in glass jars, and before refrigerating, was an excellent means of destroying yeast and mold, it caused the slices to look like canned peaches and were not considered fresh. Though the flavor was good, it was not that of "fresh" peaches. Heat (120°-130° F.) in combination with sodium benzoate-potassium sorbate preservatives accelerated softening and fragmentation of slices.

10. Peach flavor is not improved by adding slices of other fruits. Fresh peach flavor has characteristics peculiar to itself, and efforts to accentuate it by adding slices of pineapple, orange, grapefruit, lemon and cherry, were unsuccessful.

Steps in Preparation

1. Grade for large size, uniform table ripeness and freedom from defects. Use inclined grader which gently rolls peaches for mechanical removal of small fruit and hand removal of unsuitable fruit. Place underripe fruit in ripening room, or chill overripe fruit.

2. Peel by immersing in 5 percent lye at 210° F. for about 30 seconds.

3. Remove loose peel in rotary washer using very fine sprays.

4. Brush lightly with soft nylon brushes and trim with knife to remove soft or rotten spots.

5. Rinse whole fruit in bath of 0.5 percent citric acid, 0.15 percent ascorbic acid and 0.05 percent sodium benzoate.

6. Deseed and hand or machine slice.

7. Fill jars with uniform weight of sliced peaches and cover with syrup (20°-30° Brix).

8. Close jars with 15 inches of vacuum.

9. Cool jars rapidly to 30°-32° F. with water or spray.

10. Turn jars for thorough mixing and store for as long as 12 weeks.

FULL-FAT SOY FLOUR

by
E. L. Griffin
Northern Utilization Research and Development Division
Peoria, Illinois

The increasing world need for inexpensive high quality protein foods, has been broadly indicated, particularly for people in certain developing nations. In the United States this need immediately throws the spotlight on soybeans as the major potential source. They are the only large U. S. crop grown specifically to produce protein meal and food oil and they can be grown profitably throughout a considerable portion of our

crop-land areas. But perhaps more important to our farm and national economy is the fact that these can be sold competitively in world markets at U.S. prices. The problem of how best to use soybeans in food will differ from area to area because of differences in national taste preference and in basic food needs. Thus, supplying soybean protein products for diet supplementation in developing countries presents quite a different problem from preparing soybean products which can be sold competitively in the United States. One avenue for using soybeans to supply protein foods is through full-fat soy flour. This product has the simplicity of combining all of the soybean protein and calories in a single product.

Now let us see what "full-fat soy flour" is.

Table 1.--Typical Composition of Fully Toasted Full-Fat Soy Flour

	%
Protein	44
Crude fat	20-22
Carbohydrates	27
Minerals	4.5
Moisture	3-5
Lecithin	2.5
Crude fiber	2-3
Granulation	98 (Thru 100 mesh)

It will include all of the soybean except the hull. It would be suitably heat treated, toasted, or otherwise processed to varying degrees to destroy antinutritional factors while maintaining its desirable nutritional characteristics and, at the same time, improving palatability.

For some uses where a higher protein solubility is desired, relatively little heat treatment may be applied, but such flours are then incorporated into products to be baked or cooked before being eaten. For general consumer applications, the fully toasted flour shown in this table is more versatile.

The soy protein contains a good balance of the amino acids essential to human nutrition and, in this regard, tends to be comparable to animal proteins. It is a particularly good source of lysine which tends to be lacking in cereal proteins. Our extrusion-cooked products average about 5.3 percent available lysine. Although the methionine content is perhaps lower than would be desirable, this lack tends to be supplied by the proteins in cereals supplying carbohydrate to the diet. Thus the soybean and cereal proteins can complement each other nutritionally.

The soybean fat ranks as a nutritious highly unsaturated food oil. Of the vegetable oils commonly used for food in this country, only safflower oil is more unsaturated.

The carbohydrates include about 6 percent sucrose and only a trace of starch. The bulk of the remainder is stachyose (6 percent), raffinose (1.5 percent), pentosans (5 percent), and galactans (4.5 percent); these are of more dubious nutritional value. They, of course, include the crude fiber.

Incidentally, this table adds up to more than 100 percent, because the items listed are not additive. The lecithin would be largely included as part of the crude fat.

The flavor of full-fat soy products can be relatively mild or bland, but it will tend to have some typical soybean characteristics.

The degree of fineness is optional. The processed material would be available as a coarse product which would have desirable textural properties for some types of foods. It can be ground to grits of various sizes. Here, however, I am primarily considering the finely ground product.

This is a highly concentrated food. The protein and fat constitute about 65 percent of the total weight of the flour, and they are of particularly high nutritional quality for people.

Why then is this wonderful food not in broader use? A part of the answer certainly lies in the characteristics of the soybeans themselves, but the history of their development and the general unavailability of really good soy protein food products have been very important factors also.

As late as 1929 (Figure 1), production of soybeans in the United States was reported at a little less than 10 million bushels. Large expansion of this crop has occurred only in the last 15 years. Soybeans are now the fourth most valuable U.S. farm crop. In the early years, soybeans were grown primarily as a vegetable oil source with a residue meal to be disposed of, but as processing methods were developed to yield

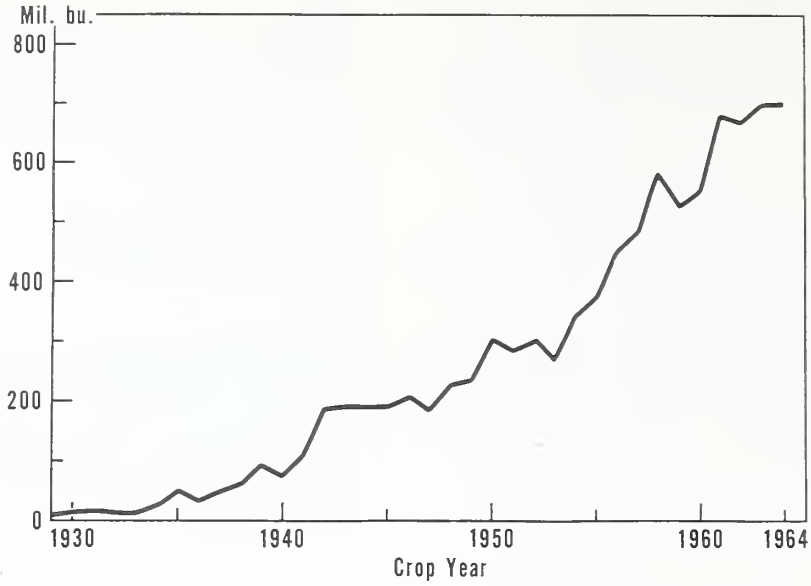

Figure 1.–U.S. Soybean production, 1929–64.

good feed meal and as the value of this meal for animal feeds became evident, the demand for the meal has increased so that it now tends to exceed the demand for the oil.

The feed meals are not sufficiently palatable for human foods. Americans have therefore tended to consider soybean meals only as animal feed. During the last war, some soy flours were produced for food use, but these do not appear to have been ideal products and apparently they were frequently misused. It has only been relatively recent that really good food products have become commercially available.

Americans as a whole are still not accustomed to soybean protein products. Few if any American foods exist which make major use of soybean proteins in a recognizable form, although sufficient varied specialty use has been made to demonstrate their food value. Such uses include special vegetarian protein foods, weight control beverages, soy milk for allergic babies, and other special dietary foods.

A number of soy flours and grits containing varying amounts of fat are now marketed to contribute desired physical characteristics in U. S. foods. These products are generally quite good. They are used in many foods where their functional properties can improve the product with relatively small additions. By holding moisture in baked goods, they retard staling and maintain softness; they seal out excessive oil during frying as in doughnuts; they improve dough handling properties; and they provide an emulsifying action which stabilizes processed meats. If you read the content label on cooky and cracker boxes you will probably be surprised at the number that list soy flour.

In these and similar uses, the soy flour or grit is completely submerged and is not recognized as a soy product.

Emphasis is on a "bland" flavor, and any flavor contribution at all is considered undesirable. This leaves us with the Alice-in-Wonderland desire that the soy flour shall taste like what we want it to taste like. In baked goods it should taste like wheat; in a beverage, it should taste like cow's milk; and in a meat product, it should taste like the meat used. This is of course not possible, but in small additions the flavor contribution is minimal.

For the broadest use of soy protein, we need to gain some acceptance of a mild characteristic flavor in soy protein products, and this must include the development of desirable consumer foods compatible with this flavor.

We cannot assume that peoples in need of protein supplementation in their diet will prefer the types of food we desire. On at least one isolated occasion, several Africans indicated a preference for a soy beverage

over a reconstituted skim milk, and it has been indicated that accepted favorite American flavorings may not be universally desirable to other peoples.

Introduction of foods of an unfamiliar type can be expected to take considerable time for acceptance, perhaps generations, but any voluntary use is a springboard from which more acceptable and desirable food forms may evolve and greater acceptance can develop through continued use. Use in feeding young children should be an excellent method for at least accustoming these children to soy protein foods.

Getting back again specifically to full-fat flours at least two companies now sell these products in the United States, and I believe they are pretty good food products. I am not aware that they are widely advertised or distributed to consumers, but perhaps there is relatively little need or insufficient recipes using them available to interest many consumers, and they certainly are not traditional American foods. This leaves a broad opening to develop American markets.

However, our recent interest in full-fat soy flours at the Northern Regional Research Laboratory has been aimed initially in a somewhat different direction. Several years ago, we were contacted by Max Milner with regard to the development of a small-scale soy flour production method for UNICEF. They were particularly interested in a practical process, which could be carried out near the point of use in various areas of the developing countries where supplementary protein food are needed. Full-fat soy flour looks most promising for their purpose because it makes maximum use of the soybeans and because it can be formulated into a beverage of potential value in feeding young children.

Following their request we set out to explore the possibility of extrusion cooking as a major step in the process. The results of our preliminary test run in cooperation with Wenger Mixer Manufacturing, at Sabetha, Kansas, were so promising that UNICEF financed a full-scale series of tests in collaboration with our Laboratory and Wenger.

Complete facilities for production tests on industrial-size equipment were not available at any one location, and product testing required the facilities of many types of laboratories. The facilities of over 20 companies and institutions were used for the processing and testing.

In developing a system for the cooking of whole fat soybeans, the objectives were: (1) to achieve a cooked soy flour product with a high biological value; (2) to cook the beans adequately to control the growth inhibitors found in soybeans; (3) to produce a bland and palatable product which should be substantially free from unpleasant bitterness or beany taste, and (4) to produce a product with adequate shelf life without refrigeration.

The process is carried out as shown in figure 2. The beans are cracked, dehulled,

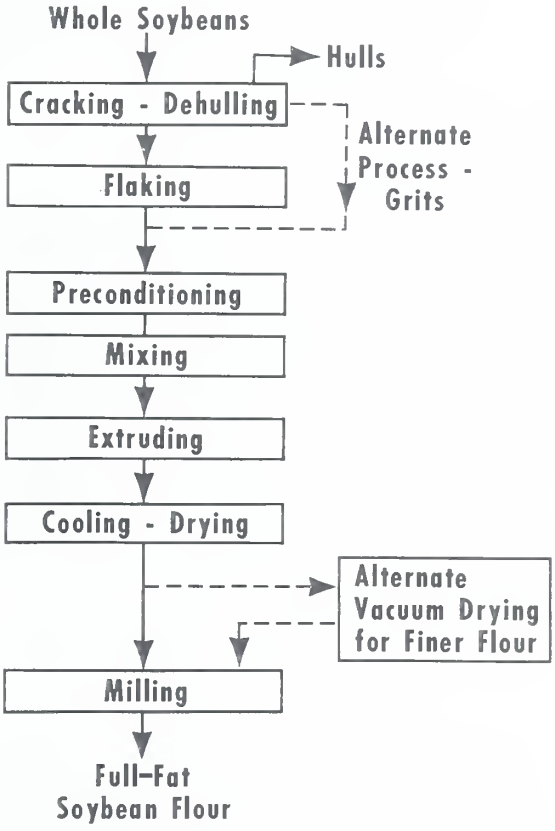

Figure 2.—Continuous extrusion process for the production of full-fat soybean flour.

and flaked or ground to a grit. They are then preconditioned with open steam injected to add water and heat, extrusion-cooked, cooled, dried, and milled to the desired degree.

For the production and evaluation tests 9 tons of soybeans were dehulled and flaked to approximately 0.010-inch thickness.

These were extrusion-cooked in a series of 12 tests in which moisture, temperature, and retention times were varied to establish desirable operating conditions.

Figure 3 shows the arrangement of the extruder cooker assembly. Flakes were

Throughput was approximately 70 lbs. per minute. This provided a retention time in the preconditioner and mixer of approximately 3 minutes.

The extruder-cooker used had the configuration shown in figure 4. It is a Wenger

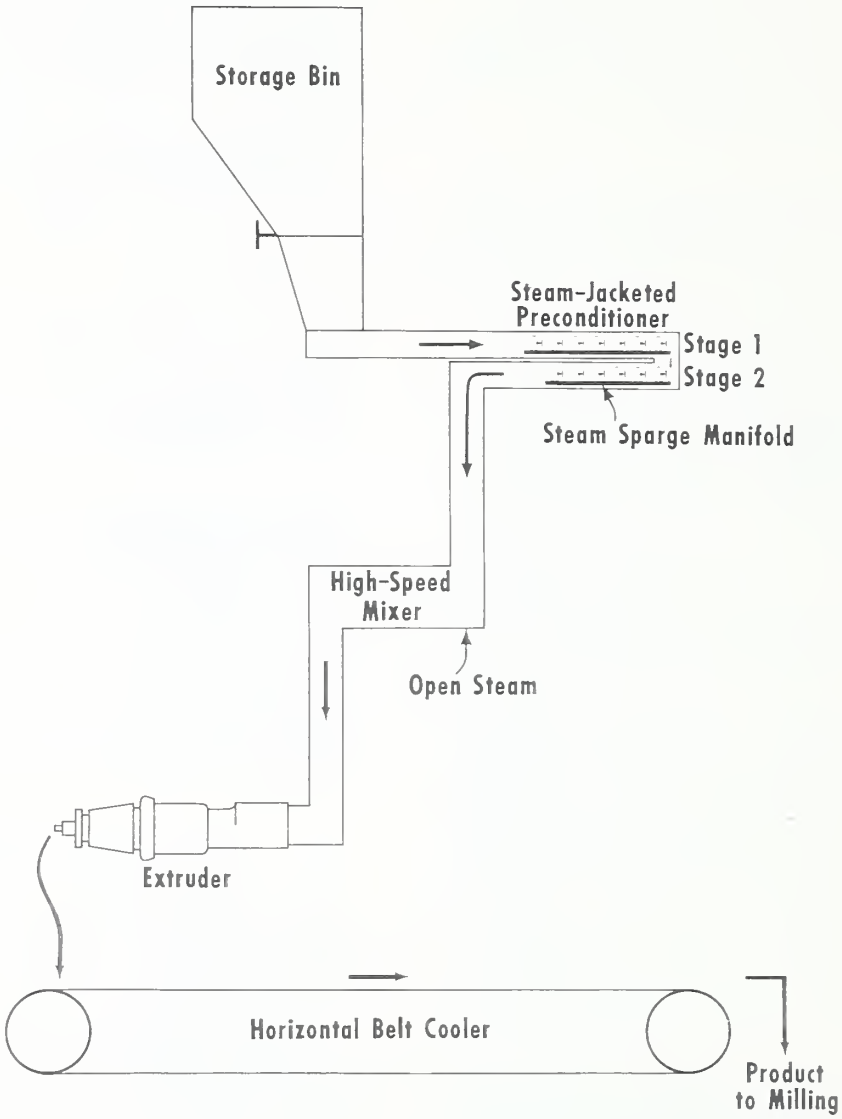

Figure 3.--Equipment layout for preconditioning, extrusion, cooling and drying steps.

received with an average of 9.0 percent moisture, and it was anticipated that the preconditioner would add approximately 9 percent as steam, bringing the product up to 18 percent moisture on extrusion. Or by adding 3 percent extra moisture to the original flakes, total moisture at time of extrusion was raised to about 21 percent.

production model. The screw forces the meal through the unit from right to left building up pressure and temperature in several stages separated by the two internal dies. Maximum temperature is reached in the cone nose section just before final extrusion to atmospheric pressure. The first two segments are steam jacketed, but heating is

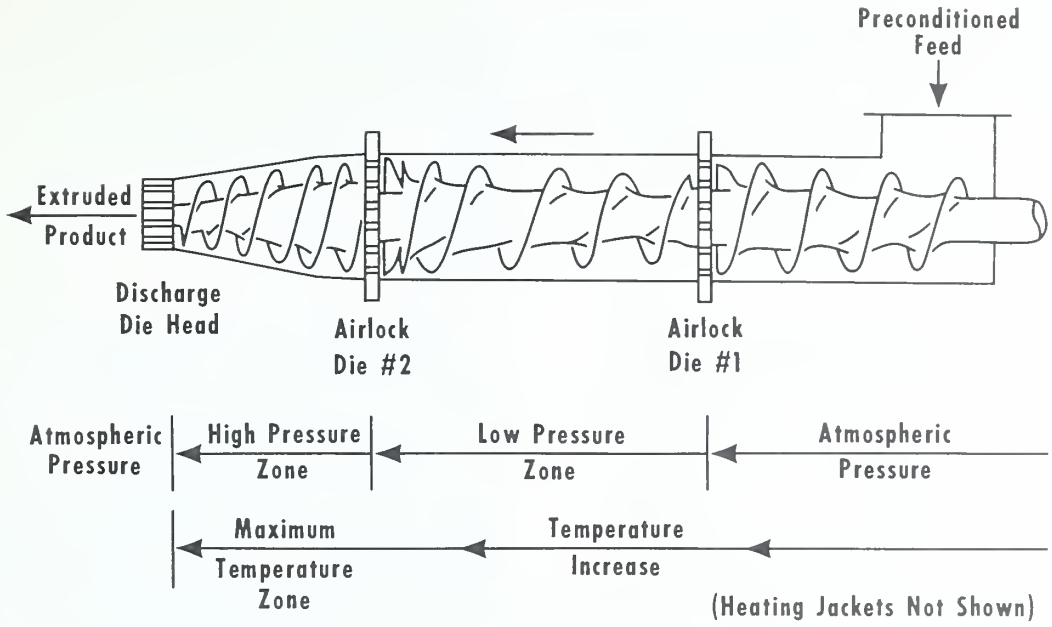

Figure 4.–Extruder screw standard configuration.

accomplished primarily by mechanical friction of the screw on the material, particularly in the final section. Retention time in the extruder shown here was 1 minute. A retention time of 1-1/2 minutes was obtained by adding a fourth segment, like the central section. During extrusion, oil is expelled and freed from the cells but as the beans extrude from the final die plate the oil is immediately reabsorbed in the meal. Freeing of the oil from the cells should make it readily available for nutrition.

Figure 5 is a temperature profile of the cooking process. Temperature rose to about 200-210°F. during preheating and to 210-220°F. in the mixer. Extrusion temperatures between 242° and 290° F. were obtained. Satisfactory products were produced throughout this range but the higher temperatures tended to give improved flavor scores.

The product was cooled and dried on a continuous horizontal belt cooler. For preparation of test samples the grits were

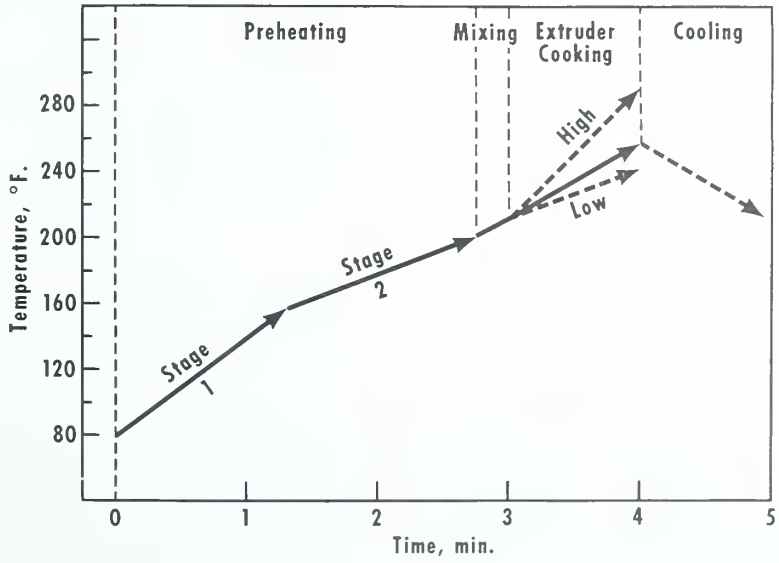

Figure 5.–Time-temperature profile of the cooking process.

vacuum dried to approximately 4 percent moisture. A laboratory-size smooth roller mill at the Northern Laboratory then successfully milled this product to a flour of 95 percent through 100 mesh. Large samples for clinical testing programs were predried and milled on an industrial-size pin mill which had a large capacity airswept chamber. Flour with 98 percent through a 100-mesh sieve was obtained.

You will note that in this process the beans are held at elevated temperatures for little more than 2 minutes as contrasted to conventional commercial soybean feed meal toasting at about 212° F. for 30-45 minutes.

The short cooking times with extrusion cooking minimize damage to nutritional properties but adequate removal of growth inhibitors was obtained as reflected in table 2

Table 2. --Removal of Growth Inhibitors

Urease activity, pH change (Caskey-Knapp)	0-0.06
Trypsin inhibitor assay, % inhibitor destroyed	95.1-99.1

by the trypsin inhibitor and the urease activity assays. All representative products analyzed 95 percent or higher of trypsin inhibitor destroyed and had very low to zero urease activity.

Assays were made for thiamin, riboflavin, and niacin on the uncooked flakes and on two of the products (table 3). There was no

Table 3. --Vitamin Analysis

	Thiamin	Riboflavin	Niacin
	micrograms per gram		
Original flakes	9	2.9	50
Extruded F. F. flours			
Test A	9.9	3.1	63.0
Test H	9.5	2.9	47.0

significant loss of these materials during processing.

Feeding tests with broiler chicks at the University of Maryland for 4.5 weeks showed the extruded product to be about equal to a good quality commercial full-fat soy flour or to a defatted flour reconstituted with soybean oil both in promoting growth and in efficiency of feed conversion (table 4). In these tests, 1,400 broiler chicks were maintained in floor pens and fed rations containing identical levels of protein and fat from the three products. Supplementation studies with methionine showed about equal improvement in each case. Considering the varied sources of the meals these test results are all quite close together.

The soluble protein or nitrogen solubility index (NSI) reflects the degree of heat treatment received by the product. Figure 6 plots the NSI against temperature reached in the extruder cone nose section. The values ranging from 13 to 21 show a very rough inverse trend with maximum temperature, lower protein solubility being associated with higher temperature. The line constructed by the method of least squares generally confirms this trend.

While a higher NSI value may give desirable functional properties for use in certain products such as doughs, the product at 15-20 NSI has more general potential for use in consumer foods where it may be employed with or without additional cooking. When mixed with hot water it forms a dispersion and remains reasonably well dispersed for a period of several days. The texture of this beverage is fairly smooth, but less so than fresh cow's milk.

In organoleptic evaluations by the Northern Laboratory taste panel the extrusion-cooked flours scored relatively high with regards to blandness of flavor and were not bitter or rancid. They compared very favorably with a commercial soy flour. Accelerated storage tests were conducted at 100° F. and 113° F. for up to 9 months. At the higher temperatures, good stability was exhibited through the first 9 weeks. At 100° F. good stability was indicated throughout the entire 9 months period as determined by odor, taste, free fatty acid, and peroxide value tests. Extrapolation of this data by previous experience to 70° F. storage indicates that the extruded flours should have good stability for 1 to 2 years.

UNICEF has sent approximately a ton of the full-fat flour from these tests to Taiwan and Indonesia where it has been formulated and packaged for clinical and acceptability testing in infant feeding programs. In these tests it is formulated with sugar and supple-

Table 4. --Results Obtained with Growing Broiler Chicks Maintained in Floor Pens and Fed Rations Containing Identical Levels of Protein and Fat from Soybeans

Added Methionine % [1/]	Control Soybean Oil Meal + Soybean Oil	Commercial Full-Fat Soy Flour	Extruded Full-Fat Soy Product
	Ave. 4.5-Week Body Weight, g.		
--	606	589	613
0.073	650	627	625
0.145	678	646	653
	Feed Consumed/Unit Weight (0-4.5 wk.)		
--	1.57	1.65	1.58
0.073	1.54	1.62	1.52
0.145	1.50	1.53	1.50

1/ Basal ration contained 34.35% dehulled soybean meal (48.43– protein), 1.47% fat, and 52.92% corn as only protein sources. Rations calculated to contain 21.4% protein.

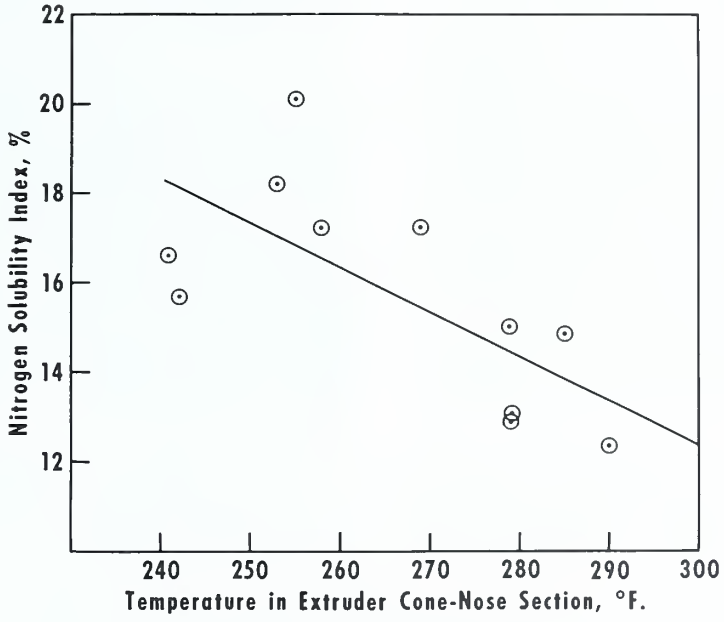

Figure 6.–Effect of extruder temperature on nitrogen solubility index.

mentary vitamins and fed to children up to about 12 months old in comparison with various milk and vegetable protein products.

Reports from Dr. Tung in Taiwan have indicated our full-fat soy flours give excellent growth and development in infants as young as 4 months. Results have been virtually comparable to those obtained by feeding cow's milk.

The Food Quality Laboratory of the Human Nutrition Research Division at Beltsville has been studying the use of some of this same extrusion-cooked full-fat soy flour in various food products, including biscuits, cookies, noodles, tortillas, unleavened bread, and yeast bread. Mrs. Georgia C. Schlosser, who is in charge of this work, reports they are pleased with their preliminary test products.

The results of these processing and food studies indicate that a full-fat soybean flour of high nutritive value, mild flavor, and good oxidative stability can be produced by the extruder-cooking process. Growth inhibitors are effectively destroyed, while the heat-labile amino acids, vitamins, and other nutrients are preserved. The process largely removes objectionable taste characteristics as shown by good taste panel acceptance scores. These studies were carried out in commercial-scale equipment which is highly compact for its capacity due to the very short retention period. The process, therefore, could be incorporated into a compact high efficiency processing unit for installation in the developing countries as desired by UNICEF.

This brings us up to the present. Our studies on full-fat flour production are continuing under Agency for International Development (AID) sponsorship as a part of a larger project examining soybean, cottonseed, and peanut proteins as human foods.

Our part of this project has two phases, the first calls for optimizing the extrusion-cooking process, and the second phase will develop simpler processing methods requiring less complicated equipment to produce high-quality, full-fat soy flour than that currently used or proposed for the cooker-extrusion process. The exact assembly of equipment will depend on the production scale desired and the state of technology in the country for which the unit is intended. This approach presumably could accept a considerable amount of hand labor and time-consuming operations which would be uneconomic in the United States.

Initial studies for this simplified process are considering cooking methods. Possible cooking processes include open steaming, water-immersion cooking, and dry heat or roasting.

Preliminary studies show that high-initial moisture greatly speeds the cooking rate. Thus soaking the beans in water overnight greatly reduces the steaming or immersion-cooking time required to destroy urease activity and fully cook as indicated the moisture to 60 to 70 percent. Indications are that tampering to some lower moisture content may allow an adequate cooking rate and this combined with control of the water absorbed during cooking, for example by steaming or roasting, may be found practical. Work is continuing to determine optimum cooking conditions.

Finally, I would like to re-emphasize what appears to me to be the greatest single need in the development of soybean protein foods. This is the development of low-cost foods that are not only passively acceptable to people, but that are sufficiently good that with familiarity, people can come to actively desire them. To accomplish this, a full-fat product makes the most direct and complete use possible of the nutritional value of the soybean.

THIRD SESSION: Chairman, W. M. Roberts, North Carolina Experiment Station

SOME ECONOMIC EFFECTS OF FREEZE-DRYING

by
K. Bird
Economic Research Service
Marketing Economics Division
Washington, D. C.

Economics is the study of how resources are used to satisfy man's wants. Freeze-drying is a new food processing method that produces a high quality dried food. Here we discuss how freeze-drying satisfies some human wants, what these wants are, and which and how many resources are used to this end.

Before we get into the subject of resources to be used in the neophyte freeze-drying industry, we first discuss how freeze-drying differs from other drying methods. We tell a little about some of the newer foods coming on the market and briefly outline the processing cost situation. Then, we describe some advances being made in

drying techniques. Following that, we discuss present and future volumes of freeze-dried food production. Using them as stepping-off points, we analyze substitution and complementary effects of these food items.

How Freeze-Drying Differs from Other Drying Methods

We assume that most of us understand the basic mechanics involved in freeze-drying (1). Briefly, the process is one in which a frozen food is placed in a vacuum chamber in which pressure is lowered to pressures as low as 300 to 500 microns. In a low-pressure atmosphere, such as this one, the phenomenon of sublimation takes place. This means that the ice in the food can go directly from the solid state to a gaseous vapor. We find this taking place naturally, and Sam Tease of Strokes likes to use this clothesline example: In the North in the winter, housewives hang their laundry outside on their clotheslines. Because of below-freezing temperatures, these sheets and shirts may freeze and get as stiff as boards. Later, as the wind blows through them, the ice transforms to water vapor and there is no dripping nor melting. After the items of clothing are dry, they still look hard and frozen, but actually are now soft and porous.

This same thing happens to foods in a freeze-drier. When ice has disappeared from the foods, they are left spongelike and porous. They look somewhat like the initial frozen product insofar as shape and size are concerned. But they are much lighter in weight for now they contain only about two percent water. They are so dry as to be brittle. Generally, their color lightens, but returns to normal when water is added during rehydration. A few flavors and nutrients are lost during freeze-drying, but these losses are negligible when compared with losses occurring with most of other drying methods.

In the more usual methods of drying, water evaporates from a liquid to a gas. When water evaporates from its liquid state, it carries with it oils which contain flavor solids in solution. These soluble flavor solids and nutrients travel from the interior of the product to the surface of the food where they may be deposited on the surface of the dried food item. Shrinkage simultaneously takes place as the moisture migrates and the cell structure collapses. Consequently, the dried product may become "case-hardened." On the product surface, these salts and oils have solidified and form a moisture-resisting barrier. They are difficult to rehydrate and most times will not come back to their original state.

The most important difference between freeze-drying and other drying methods is that, although both are water removal methods, freeze-drying uses sublimation and the rest use evaporation. Sublimation is the secret to the high-quality foods processed.

Cost of Processing

We currently hear discussion about costs of freeze-dry processing as more and more firms put products on the market. By far the most comprehensive and complete cost study has been our own in Agriculture, the one we released to the public a little over a year ago (2). That publication had as one objective to anticipate what costs of processing would be, for various sized firms, under given conditions. It was shown that a plant having a capacity of removing four tons of water per 24-hour day could expect costs ranging from 8 to 14 cents per pound of water removed. (This was for chicken on an eight-hour drying cycle. Products such as strawberries, with longer drying cycles and more limited tray loading, would have costs considerably higher.) These cost projections were collected two to two and one-half years ago, at a time when the industry was much newer than it is at present. However, even now they appear to be fairly accurate estimates of the processing costs involved in freeze-drying. We made a few errors in estimating input factors, and most of them had the effect of portraying costs too low--about five to ten percent lower than they should be. In spite of these criticisms, they are fairly close cost projections.

I have recently observed some bid prices of new freeze-drying equipment for a medium-sized plant of 3,000 to 5,000 square feet of shelf area. Bids ranged from about $128.00 per square foot of shelf area to $170.00. Our estimates in the above-mentioned publication were $150.00 per square foot of drying shelf area for a plant of 2,000 square feet, $145.00 per square foot for a plant with 4,000 square feet of shelf area, and $130.00 per square foot for a plant with 8,000 square feet of shelf

area. Thus, our equipment estimates were fairly close to present conditions. Other input costs were equally satisfactory.

As a generalization, I would say that most freeze-drying processors' costs are now in the range of $0.15 to $0.30 per pound of water removed. This would be equivalent to 10-1/2 to 21 cents per pound of frozen input product, or 35 to 70 cents per pound of dried food. These estimates are borne out by current charges of some custom freeze-drying plants that charge 18 to 26 cents per pound of incoming frozen product. Of course, processing costs vary considerably from one product to another, with scale of the plant, and how many hours per year a processor can operate his plant. It should be mentioned too, that my estimated processing costs are much higher than most of those now being quoted. However, when I see processing costs in the range of two to five cents per pound of water removed, my first thought is that someone has dropped a decimal point. Under present conditions, costs that low seem quite unrealistic. Drying cycles for many products are 20 hours or longer, and with just one drying cycle per day, no matter what other economies are put into effect, costs are going to be at a high level. Later we will discuss some of the newer drying techniques that may help to lower future drying costs.

New Freeze-Dried Foods

One of the most interesting aspects of the freeze-drying industry is the new foods currently being tried on the market. This area is little understood for few facts are available to the public. Secrecy is involved in market testing, and is considered necessary to carry out a successful test. This is probably true. In market testing of new products it is extremely difficult to assess the product appeal as versus the appeal of the package, the brand name, or even the promotional program being used.

At present, there are at least three freeze-dried coffees being market tested in the United States by three different companies. There are several soluble freeze-dried coffee plants under construction (one in Texas and one in Florida) so, later this year there may be five companies freeze-drying coffee on this continent. Brazil seems to be a natural location for soluble coffee drying plants, and there are several plants being planned for location there. In Europe, too, freeze-dried coffee is attracting much attention. One plant is being built in Spain and one in France. Probably other European ones are being built or are in the drawing board stage.

Next to coffee, probably no freeze-dried items have created more interest in the U. S. freeze-drying industry than the fruits and berries. One prominent food processor tried strawberries with a breakfast cereal. This same company then followed this market test with peaches in a cereal. Later, freeze-dried blueberries were tested in cereals. Little information is available on the results of these tests, but apparently they were successful, for a competitive company has now been market testing its own fruits with cereal. A third cereal company is market testing freeze-dried blueberries in muffin mixes. While on the subject of dried blueberries, we might mention that the explosive puff-dried blueberries (developed by USDA) are a fine product for uses where the berry needs to be cooked. They do not readily rehydrate if not heated though. However, their processing costs are much lower than freeze-drying processing costs.

Another fruit of interest in the cereal market is freeze-dried bananas. These are presently being market tested by one company and at least two other companies, one in the United States and one in Brazil, are gearing up for production. Banana powders and flakes, as well as slices, are of interest on the freeze-dried basis.

A large dairy company has been testing omelets that contain freeze-dried ham and mushrooms. Because Americans are not so "omelet-minded" as Europeans, these may not be so popular as one might expect. This same company now market tests some freeze-dried entree products and sauces. The meat company that had a group of entrees on market test has discontinued them as well as its mushrooms tailored for household use. One leading soap company has a group of freeze-dried dinners on the market. Sales are said to be good and are expected to improve. A large tomato product company now has freeze-dried dinners and sauces designed and ready for market testing late this spring. There seems to be a definite trend towards putting cooked, seasoned, and fully prepared dinner and breakfast items on the market. Food processors keep probing the market to determine areas where freeze-dried foods appear

to have the greatest chance of success.

There appears to be a decided trend towards using the flexible-pouch package. The only rigid containers now on the retail grocery shelves are the one brand of dried soup in an extruded aluminum can, chives in glass jars, and the soluble coffee in jars. At the institutional and remanufacturing levels the can and drum are still prevalent and widely used. Incidentally, chives appear to have successfully gone through the market testing stage and are now in almost nationwide distribution. At least four processing companies are now or have been drying them, and several companies are marketing them. Sales of cottage cheese are widely distributed and may attain nationwide sales this year.

So far as I know, freeze-dried ice cream has not yet reached the market test stage. It's so novel and unusual, though, that I predict that several firms will have sufficient interest to test it.

Many other new and different freeze-dried items are still in the laboratory or very beginning stages of development. Strawberries or cherries as fillers in candy seem to have possibilities. Freeze-dried beer and wine have long been novelties and as costs of processing decline may have a market potential. One processor is drying squid on a commercial basis. This is for a specialized market. Others are drying shrimp for fishermen to use as bait. Soluble freeze-dried tea has not yet reached the market testing stage in the United States, but I feel it only a matter of time until it does. It's now a commercial product in England. In Europe leeks and several other new vegetables are now being dried in fairly large quantities. This is in addition to vegetables that have been dried commercially for several years. Dairy products, too, seem to be more popular on the Continent than here in the United States.

Advances in Drying Techniques

Although most freeze-dried foods now require cycles of 8 to 24 hours, changes now under investigation may shorten the cycle. A new microwave system is designed to be used in freeze-drying cabinets during the latter phases of drying. This heat application method allows up to 5 pounds of food to be loaded per square foot versus the usual 2 to 3 pounds. Cycle times may be reduced from 8 to 4 hours. As a result of improved efficiency, total equipment investment may be reduced by about one-third and will appreciably lower drying costs.

Another innovation of the future is the continuous dryer. Drying plants are now getting large enough to where multiple chambers may no longer be the most practical and economical means of drying. As products become more standardized it is easier to design a continuous plant. The system will work best with dices, powders, or liquids. In coffee, for instance, a continuous plant seems indicated. Savings in heating up, drying out, and lowering pressures are possible. Usually these functions are geared to cycles and are eliminated in a continuous plant. Material-handling savings are also possible and more easily attainable when we consider the flow concept rather than the batch idea.

Some changes come about in an evolutionary way. For example, vapor removal from a cabinet has always been a key problem. Putting the condenser plates in the drying cabinet itself, or putting them in an adjacent cabinet with a very large opening between them seems to be a gradual change. If this latter type equipment has an auxiliary condenser, the large condenser may be defrosted while the cycle is in progress. This and other ideas help to cut down on the "between cycle" or "down time". Other ideas that help cut down the down time include having doors on both ends of the cabinet, having a tray cart on wheels, or having a tray cart hung from a monorail. Most ideas of this type increase investment, lower the amount of labor needed, and help overall efficiency.

Present and Future Volumes of Freeze-Dried Foods

Because of the confidential nature of the market tests now being conducted, estimates of freeze-drying volumes are difficult to make. Recently, I have calculated that the 1964 volumes of freeze-dried foods were approximately 25 million pounds of frozen input product. This would be about 8 million pounds of dried food and 17 million pounds of water removed. Of this quantity about 12 or 14 percent went to the Quartermaster Corps, and the remaining went to the commercial market. Main

products processed were chicken, beef, mushrooms, shrimp, crab, coffee, strawberries, pork, ham, green beans, green peas, chives and peaches. This volume of 25 million pounds of frozen food dried is more than double my estimate of 11 million pounds for 1963 and is roughly 4 times the volume of 6 million pounds in 1962. This doubling effect is a normal situation for a new product. If a new product does not at least double its volume each year for the first few years, it probably will not have a very great impact on the market.

At various times during the past few years I have looked into my crystal ball and estimated the future growth of the freeze-drying industry. The first time (August 1962) I predicted the 1970 volumes of freeze-drying would be about 500 million pounds (3). About a year ago I tried to use a little more precision in my estimating procedure and came up with 250 million pounds for 1970 (4). Several months ago I tried another method and came up with the figure of 317 million pounds for 1970 (5).

For the sake of some place to start, let us say that the freeze-drying industry will have a volume of 250 to 500 million pounds of frozen input food. This would be about 43 to 86 million pounds of dried food. How does this compare with some of our other well established food processing industries? Compared with either the canning or the freezing industry, freeze-drying is small--almost negligible--in size. Canning, for example, has volumes of about 21 billion pounds of food annually. The frozen food industry has volumes of about 9 billion pounds of frozen food per year.

Dehydrated and dried foods, other than freeze-drying, have a volume of about 5.7 billion pounds annually. This does not include dates, figs, prunes, and raisins which total about 603 million pounds per year. Nor does it include citrus pulp (about 622 million pounds). Neither does it include skim milk used for animal feed (28 million pounds) (6). Even with the promising growth prospects anticipated, freeze-drying will be small compared with these other more prominent food processing methods.

Some Labor and Capital Needs Brought About by Freeze-Drying

It has been previously estimated that if the freeze-drying industry were to reach a volume of 250 to 500 million pounds of frozen input product in 1970, labor requirements would be fairly small (4). There would be about 700 to 1,300 workers directly involved in the drying operations. Other workers would be involved in product procuring, food preparation, freezing, packaging, warehousing, promotion, and sales. These may number from 6,300 to 11,000 by 1970.

With square feet of shelf area used as a basis for estimating amount of freeze-drying equipment, the annual investment by 1970 would be about $10 to $20 million. This is based on shelf area requirements being in the range of 206,000 to 410,000 square feet. This compares with today's industry which has 56,000 square feet of shelf area (7).

Freezing equipment investment additions are based on freezing equipment designed to freeze 250 to 500 million pounds per year. If the 250 million pounds of frozen foods were frozen in an average year of 200 days, this is 1-1/4 million pounds per day. If the equipment were used 20 hours per day, this would be 62-1/2 cwt. per hour. If we use the rule of thumb of 1.5 tons of refrigeration needed for each cwt. of food frozen per hour, our refrigeration for freezing the food is 938 tons. If the freeze-drying industry has anticipated volumes of 500 million pounds of frozen food per year, refrigeration tonnage at that time (needed for freezing the food) is about 1,875 tons. At $1,400.00 per ton of refrigeration, the investment is $1.3 to $2.6 million. This is only for refrigeration equipment for freezing the food to be freeze-dried.

Sublimation needs about 10 tons of refrigeration equipment for each 100 pounds of water removed. With 250 million pounds of frozen food, we sublimate about 175 million pounds of ice. If the industry averages 175 days per year, this is 1 million pounds of ice sublimated per day. On an average 20-hour day, this is 500 cwt. per hour of operation. Ten tons of refrigeration for each cwt. per hour gives us a figure of 5,000 to 10,000

tons of refrigeration capable of minus 40° F. temperatures. Thus, we see sublimation is the great user of refrigeration--about five or six times greater than needed for freezing the food. We would expect total refrigeration investment to be $10 to $20 million in 1970. Refrigeration needs other than those discussed, include holding rooms for the frozen product, low moisture, and air conditioned rooms for packaging the product.

Some Complementary Effects of Freeze-Drying

In the field of economics, complementary means that if one good is increased in use, another good is also directly affected. An example might be that if a housewife buys hot dogs, she may also buy some complementary products such as hot dog buns, mustard, ketchup, onions, and napkins. Even soft drink and potato chip sales may be increased. In the field of freeze-drying we can expect containers, shipping packages, and equipment sales to increase as freeze-drying increases.

A complementary industry that might expect its volumes to increase at a constant ratio relative to freeze-dried food production is packaging. For our little analysis let us again assume that by 1970 the freeze-drying industry would have volumes of 250 to 500 million pounds of frozen food. This is a production of 80 to 160 million pounds of dry food. If half this production were to be packaged in flexible pouches, this volume would be 40 to 80 million pounds of dried foods per year in 1970. If 1/2 of the pouch-packed product were in 2-ounce packages, 1/4 in 3-ounce packs, and the remaining 1/4 in 4-ounce flexible packages, annual needs would be 253 to 506 million flexible packages. If every two pouches are packed in a cardboard container, the industry would need 125 to 250 million of these boxes. If every dozen retail boxes needed a fiberboard shipping container, we would need 10 to 20 million of these. Similar figures could be budgeted for cans or other containers needed for the half of the freeze-drying food production not accounted for in the above analysis.

Substitution Effects of Freeze-Dried Foods

Determining the effect of the growth of the freeze-drying industry on farmers, wholesalers, retailers, and other interested groups is not easy. It depends upon how these new foods fit into our marketing system. Will they increase our eating? Will we eat more? It is doubtful. Most likely they will substitute for other foods. But, what will they substitute for? It is difficult to make generalizations, and even dangerous at times, but let's take a look at some of the specific freeze-dried products that appear to have the greatest future potential and discuss their substitution. I think that freeze-dried coffee will probably replace spray-dried coffee. It might even cut into a little of the market for the home-brewed coffee.

As a result of the introduction of freeze-dried strawberries, I believe that total strawberry consumption will increase. My impression of these dried berries is favorable and I can imagine double or triple their use for breakfast items. This does not imply that total berry consumption would double or triple--rather, we might foresee an increase of 5 to 10 percent.

This same feeling applies to the other native fruits and berries anticipated for breakfast cereal use. This will be an increase in consumption with perhaps a slight decrease in consumption of jellies or marmalades as an offsetting factor. Bananas appear different, however, and I believe that if these become common for breakfast cereal use, ripe bananas will suffer by an almost like amount, i. e., the substitution will be almost at a one for one ratio.

With regard to mushrooms, I believe as more of them are dried and used in this manner, all other forms of them may show increased volumes. Instead of cutting into the fresh, canned, or frozen market, the total consumption will increase as people become more "mushroom-minded."

For red meats, probably both cured and canned ones will be used less as volumes of freeze-dried meats increase. Freeze-dried meats appear to fit into several specialized markets for camping, armed forces use, dried soups, dried stews, and specialized entrees. I can't imagine fresh or frozen meats being seriously affected by freeze-dried ones. With poultry meats, my feeling is that the freeze-dried ones will be net additions to the present marketings.

For the vegetables that will be freeze-dried there will be some substitutions for hot air-dried ones. There may also be

substitutions of freeze-dried ones for fresh and frozen ones. Here we are thinking of asparagus, broccoli, brussel sprouts, beets, carrots, chives, parsley, leeks, and several others. Volumes of peas, corn, and beans will be so small, when compared with the total processed volumes of these products, that the freeze-drying industry will have little or no appreciable effect on these industries.

Summary

We have shown that the relatively high processing costs, combined with specialized uses of freeze-dried foods, limits their market. Total volume of freeze-dried foods processed in 1970 may be in the range of 250 to 500 million pounds.

Other industries affected by this growth include drying equipment, freezing equipment, and containers. Most freeze-dried foods will be used as substitutes for foods processed in other ways. A few freeze-dried foods will be net additions to our diet. Freeze-dried foods will have little effect on our canning, freezing, or the fresh market sales. The food processing sector most likely affected will be foods that are now dehydrated by other means.

References

1. For a detailed description of the freeze-drying process, see Bird, Kermit, "How Freeze-Drying Works." Speech reprint, 10 pp., (March 12, 1965).
2. Bird, Kermit, "Freeze-Drying of Foods: Cost Projections," MMR-639, 34 pp., Washington, D. C., (January 1964).
3. Bird, Kermit, "Freeze-Drying--Progress and Problems." Talk to Western Farm Economics Association, Reno, Nevada, (August 1962). Washington, D. C., 11 pp.
4. Bird, Kermit, "The Freeze-Drying Industry: Projections of Capital and Labor Requirements," 1963-1970. Talk to the Philadelphia Chapter of the American Society of Heating, Refrigeration, and Air Conditioning Engineers, Philadelphia, Pennsylvania, (April 9, 1964). Washington, D. C., 9 pp.
5. Bird, Kermit, "The Awakening Freeze-Drying Industry." Talk to the annual meeting of the American Society of Heating, Refrigeration, and Air Conditioning Engineers, Chicago, Illinois, (January 27, 1965). Washington, D. C., 13 pp.
6. Bird, Kermit, "Food Dehydration's Evolution to a Promising Peace Time Industry." Talk to Western Farm Economic Association, San Luis Obispo, California, (July 16, 1964). Washington, D. C., 10 pp.
7. Bird, Kermit, "Freeze-Drying 12-Fold Increase by 1970." Article in Food Processing (March 1965).

FOAM-MAT DRYING

by
A. I. Morgan, Jr.
Western Utilization Research and Development Division
Albany, Calif.

I feel a little inadequate talking after Dr. Bird has talked so well about freeze drying, because I am obliged to go beyond merely describing what foam-mat drying consists of and tell you what its status is. And its status, compared to freeze drying, is not so good.

On the other hand, in spite of the frequent assumption that freeze drying is rather new, it is many times older than foam-mat drying. The freeze-drying process was practiced in various ways (including on foods) in the thirties.

Foam-mat drying is something quite new in comparison to that. Unfortunately, foam mat is now 4 years old in its present form. We are approaching the time when we expect it either to walk or die, and I think it is going to walk.

I feel inadequate in another way talking about foam mat after we have got our minds on freeze drying, because foam-mat drying is a method which is not as versatile as freeze drying, particularly in the sense that the possibility of drying solid pieces or pieces of any considerable size whatsoever

is completely out when it comes to foam-mat drying.

Foam mat is pure and simple liquid-foam drying. I have done my homework on this speech about a year or two ago, and this consists of that roll of film which is on the movie projector there. So if we can turn it on, I will do a little more elaborating afterwards and perhaps there will be time for some questions.

(Movie was shown at this point.)

The movie made several points which were new. One of these was our present ability to make a dry product of a sufficiently low moisture that it is stable, not caking, and remains so without having to put one of those little paper bags of lime in with the product. The disadvantage of the bags of lime is that the housewives sometimes reconstitute the lime rather than the orange. And, furthermore, the lime takes up space in the package.

This was accomplished by using a finer-bodied foam by extending the mixing time somewhat. The result of this was the very low moisture right off of the dryer itself. Because of the finer structure that is used for this purpose, we feel it is necessary to flatten out the dry foam so there are fewer inclusions of gas in it when the customer mixes it with water.

Another advantage of this flattening is, of course, that the dry density of the product is high. Now, there is almost twice as much beverage to be had out of a container holding foam-mat dried solids, orange solids, than could be made from the same container of a normal frozen concentrate. Without this compression that you saw in the movie, this is not so. The same size package of orange concentrate would give you more beverage than if it were filled with the light uncompacted orange solids.

So those are the two technical developments which the film is trying to get across.

I said I would outline a little bit about the present commercial status of foam-mat drying. I am not especially anxious to do this because I did it a few months ago in Winter Haven, and I also attributed various parts of the process to different inventors. I have never done that publicly before, and these have been the longest couple of months I have ever spent. So we will just leave that part aside and say that the commercial situation, as far as equipment is concerned, is that there are three manufacturers who are in a position to offer completely designed, packaged foam-mat dryers. One of these offers a crater dryer of the kind that you saw in this movie. Another one offers a belt of a kind that was not shown, but on which we have worked in the past. The third manufacturer offers both kinds; that is, the belt and the tray. So that part sounds fine.

But the difficulty we are encountering is in getting people--processors--to buy these units and use them. We are perhaps in a little trough of this development. I hope it is that, or we are entirely on the skids.

The trough consists of the difficulty that processors are uncertain whether they can sell the product, and the buyers of the product are unwilling to make offers because there are no very large processors in a position to fulfill their demand.

I hope we will be able to break out of this difficulty in the near future, particularly in the case of the citrus which appears to be one of the most appropriate areas for this development.

The few commercial units which have been constructed have been devoted mostly to the manufacture of tomato powder. I am not as optimistic of the future of tomato powder as I am of citrus powder because citrus powder has the possibility of fulfilling a very healthy demand for breakfast drinks in areas where there is no very widespread refrigeration and very much less frozen food distribution, such as in Western Europe and in South America. In this case, there would be a clear advantage with foam-mat drying because of its high quality, its relatively low cost (that is, relative to freeze drying, let's say), and its economy of transport and packaging. The market for tomato powder --vis a vis paste--seems narrower.

I believe that there is now only one company making citrus powder, namely lemon powder, by this method. But I have reason to believe that there will be more in the near future.

In the U.S. Department of Agriculture we have arrived at the point in connection

with this project where we are ready to recommend it, urge its adoption, and stand back of it in the sense that we stand back of any of our technical developments. That is not to say that we will refund any loss that you may incur, but we will feel terribly sorry about it.

DISCUSSION

Question: Can you use it in the place of frozen foods?

A. I. Morgan, Jr.: The question was, I don't know whether or not I should restate it because I don't think I am going to answer it, but the question was, how will the in-use cost compare frozen concentrate and powder?

I think there is a feeling that the powder in this country will be slightly more expensive than the frozen concentrate, at least in any of the early stages of the development. Naturally, this will not be the case in markets at some distance from our facilities.

Question: What was the reason for adding the triglycerides there at the end?

A. I. Morgan, Jr.: That is to get it off the drum. They are the same ones that are used to stabilize the foam for tomato and certain other powders. They not only stabilize the foam in that case but they slick it up a little bit so that it peels off of the warm drum and doesn't crumble up against the knife. In the case of citrus, we are using a soya protein, and we have to add a little bit of monoglyceride to the drum itself so that we can get the flakes off. A trace will appear in the product. Monoglycerides are edible, of course, and they will appear in the product to the extent of about 0.01 percent solids.

Question: Can you get a good sheet with low moisture content?

A. I. Morgan, Jr.: Yes, to get the sheet compacted solid, you have to choose the drum temperature such that it matches the moisture content of the powder you are putting on it. That is to say, the higher the moisture content, the lower the temperature the drum needs to be to flatten this collection of little particles out into a single ribbon. The flaking operation does not produce any appreciable drying of the powder nor, as a matter of fact, does it affect the quality.

Question: Why don't you maintain the moisture in the dry powder at the same level that it came out of the foam-mat dryer?

A. I. Morgan, Jr.: The flaking role does not change the moisture of the product.

Question: You don't add it?

A. I. Morgan, Jr.: We don't add any; no, we keep it as low as we can, but whatever this moisture is determines what the temperature of the drum should be when you get to the flaking operation.

Question: Coming back to the question of adhesion to the drum, you have doubtless tried Teflon instead of the triglyceride?

A. I. Morgan, Jr.: Well, the Teflon drum or the Teflon in the product?

Question: The Teflon on the coating surface.

A. I. Morgan, Jr.: We didn't try it. We have tried Teflon-coated trays.

Question: The same thing.

A. I. Morgan, Jr.: In the dryer they are some help but surprisingly little. A bit disappointing.

Question: Were there other additives where you put it on the drums; didn't you add something?

A. I. Morgan, Jr.: Those two sticks that the man was holding; yes, that is the release agent I was telling you about. Those are monoglycerides that we use to slick up the drum so that the ribbon comes off, and they appear as 0.01 percent in the product.

Question: Is this applied continuously to the drums in contact with your drums as they rotate?

A. I. Morgan, Jr.: Yes, sir, that is right. It is just like greasing a skillet, so to speak.

Question: What is your ideal concentrate that you start with? Secondly, what can this go up to, capacity?

A. I. Morgan, Jr.: The citrus concentrates have been used up to 70 percent. However, in the case of orange, the concentrate applied

to the dryer would have to be between 50 and 55 or 56 percent. This is merely due to the consistency of the foam required for the various operations in our particular device, and this would depend upon the technique you use for spreading the foam and cratering it.

The practical size of a commercial unit would be limited in the case of trays by a reasonable size of tray, which would probably be 4 feet on a side or 3 by 5 feet. That would mean that a machine would have to be limited to 200 pounds dried per hour.

In the case of a belt, there would be no limit whatsoever. Well, I suppose, a practical limit of 1,500 pounds, something like that. Obviously, a belt can be as long as you want it and almost as wide as you want it.

Question: Do you get any vitamin or color decrease?

A. I. Morgan, Jr.: No, we get no color decrease whatsoever. We get no detectable vitamin change in the case of ascorbic acids in citrus products. We get some slight ascorbic acid loss, a few, perhaps 10 percent, in tomatoes. But we do not get any detectable loss in the case of citrus.

I might say I'd like to add that this development that I have described here and especially the present efforts are very largely being carried out in Winter Haven by Dr. Veldhuis; and although I come from Albany, we were working with the Southern Division in its Winter Haven laboratory where there is a very nice crater-type pilot plant of the kind shown in this film, except perhaps better. Thank you very much.

NEW RAPID FREEZING TECHNIQUES

by
H. K. Burr and M. S. Brown[1/]
Western Utilization Research and Development Division
Albany, California

(Presented by H. K. Burr)

According to Tressler and Evers (11) commercial "sharp freezing" of foods began in 1861. Meats were the first products so frozen. Later the process was applied to fish, and after 1905, to berries. In spite of its name, sharp freezing was a relatively slow process since it involved freezing the foods in still air at -20 to +5°F. Heat transfer was by natural convection. Berries were commonly mixed with sugar and packed in barrels and the barrels placed in a cold room. Under these circumstances it is clear that freezing might require a matter of days, or possibly weeks.

The term "quick freezing," which was introduced around 1930, is applied to processes in which freezing is completed in a few hours, or even less. Packages of food may be frozen between refrigerated plates or in a blast of cold air in a freezing tunnel, or the food may be frozen first on a belt and packaged after freezing has been completed.

It was early noted that when most foods are frozen and then thawed, there is a marked leakage of juices out of the product. Some people thought this was caused by mechanical rupture of the cell membranes by the growing ice crystals. Taylor (9) summarized this explanation in these words: "Fish, meats, etc., contain from 60 to 80 percent water. When they are frozen slowly, the large ice crystals formed lacerate cell membranes so that the juice can, and does, escape; but when the freezing is done rapidly, the very small crystals formed are contained within the cell and do not puncture the membranes; the juice, therefore, cannot escape." This idea seems indestructible. In an article published in August 1964 we find: "Because of the incredible speed with which freezing is accomplished by the intense cold of liquid nitrogen, large jagged ice crystals do not form and puncture cell walls..." (3). Taylor stated that this explanation was wrong and then went on to discuss other possible mechanisms to account for drip.

Working in a cold room and using techniques of the mineralogist, Woolrich and

1/ National Association of Frozen Food Packers.

Bartlett (14) of the University of Texas in 1942 showed that "even when freezing is exceedingly fast, the smallest ice crystals are much larger than individual cells," and "the crystal lattice both inside the cell and in the intercellular spaces is continuous." This simply means that as the water molecules in the tissue order themselves in the form of ice, the crystal grows through the cell wall pores without puncturing the wall itself.

Meryman (7), Asahina (4), and others have pointed out that when a tissue is frozen slowly, crystal nucleation is generally confined to the intercellular spaces. Osmotic forces then cause a movement of water from within the cell to these intercellular spaces. This could cause a shrinkage of the cells away from each other and lead to cell separation in the final product. If the tissue is frozen very rapidly, perhaps there is not time for this diffusion of water through the cell wall to take place. However, we are forced to conclude that at the present time we do not have a detailed understanding of the phenomena that occur when a plant or animal tissue is frozen. In particular, it is hard to explain the extensive rupture of cell walls which does occur in certain frozen foods, as will be discussed later.

The fact is that if certain foods are frozen very rapidly indeed, by means of liquid nitrogen, the defrosted product has better texture and less drip than if conventional freezing is used [Webster et al. (12); Wolford and Brown (13)]. Liquid nitrogen freezing (LNF) is already in commercial use for freezing fish filets, shrimp, mushrooms, strawberries, avocados, mangoes, papayas, and other products (2, 3). LNF tomato slices have been test-marketed (5).

It is obvious that if an LNF food item is to compete in the market place with the conventionally frozen product, it must have sufficiently better quality to justify any necessary premium in price. The quality advantage will certainly vary from commodity to commodity and this is an area where careful, objective, and disinterested research needs to be done.

We have asked a number of people in the liquefied gas industry what the ultimate cost of LNF would be. The estimates have ranged around 3 to 4 cents per pound of food frozen. These figures are for the liquid nitrogen alone and do not include overhead, labor, etc. Since conventional freezing costs are in the neighborhood of 1/2 cent to 1 cent per pound, it is apparent that LNF will be more expensive, but there appears to be no agreement as to just how much more it will cost. The economics of the process have been reviewed by R. H. Mason (6) of the Stanford Research Institute.

It has been suggested that because of the tremendous demand for liquid oxygen in industry today, there should be a large supply of liquid nitrogen byproduct at relatively low cost. However, liquid nitrogen is not necessarily a byproduct of liquid oxygen production. An air liquefaction plant can be operated to produce entirely liquid oxygen, or both liquid oxygen and liquid nitrogen, with approximately equal efficiency.

Freezing of foods with liquid nitrogen can be accomplished by immersion (5), or spraying (9). The important things are to insure that shattering of the product does not occur because of excessive temperature gradients within the product, and that the product is removed from the freezer when its average temperature is about 0°F. Temperature equilibration within the product will occur after it is removed from the freezer and there is no point in chilling it below the temperature at which it will be stored.

One of the commercial units used for LNF carries the product through the tunnel on a horizontal belt. At the far end of the belt the product is sprayed with liquid nitrogen. The liquid nitrogen volatilizes as it absorbs heat from the product and this very cold gaseous nitrogen flows countercurrent to the belt, thus cooling the incoming raw material and making efficient use of the refrigeration potential of the liquid nitrogen.

At the Western Regional Research Laboratory we have recently addressed ourselves to the question "Is liquid nitrogen freezing necessary?" To put it somewhat differently, "Can the improved texture credited to LNF be achieved by other means?' These investigations represent cooperative research supported in part by the National Association of Frozen Food Packers. This work has largely been done with green beans because we knew that there was a texture problem in this frozen product (13).

Assuming that texture damage would be associated with microscopically visible

changes in the green bean tissue, we used histological techniques for preparing microscopic sections of green bean tissue without permitting distortion to occur. The method we now use is extremely simple and requires much less equipment and time than the customary histological techniques with their gradual dehydration and embedding procedures. We chill a flask of absolute methyl alcohol to a temperature of 0° F. and place in it several pieces of frozen green beans. The flask is left in a freezer at 0° F. for 24 hours and is then taken out and left at room temperature for an equal period. At the end of this time the pieces of bean are quite firm and it is easy to cut thin sections with a razor blade by hand. These are then examined with a 10-power hand magnifier or photographed through a microscope. At 0° F. the beans are firmly frozen, but as the methanol diffuses into the tissue, the ice dissolves in it and diffuses outward. This process bears some relationship to freeze drying, for in both cases water is removed from the tissue at a temperature well below the freezing point. This dehydration from the frozen state prevents any shrinkage or distortion of the tissue.

What do we see when we examine such sections? In green beans which have been frozen in liquid nitrogen we see an intact tissue in no way different from a section made from a fresh green bean. In a section from a bean that has been frozen slowly, for example, a commercially frozen product, we see that in the outermost layers there is a separation of the cells and some sloughing of the tissue. In this area there is no breaking of the cell walls but the cells have come unstuck from their neighbors. Deeper in the tissue there are numerous fissures, each involving rupture of many cell walls. These two types of mechanical damage are very conspicuous and with very little practice one can learn to distinguish between very rapidly frozen and slowly frozen green beans.

We would like to emphasize that the tissue damage mentioned here is not an artifact caused by the dehydration of the tissue in methanol. Sections prepared by the more conventional histological technique of embedding show exactly the same thing.

Through organoleptic appraisals we have shown that green beans frozen in liquid nitrogen and showing no mechanical damage, when cooked have a crisp texture quite comparable to that of cooked fresh beans. We have also shown that beans frozen slowly and showing microscopic damage, when cooked have a relatively flabby texture quite different from that of fresh beans.

In order to determine how fast one has to freeze beans in order to get essentially no tissue damage we built an experimental freezer. In it air is recirculated across the sample of material to be frozen and refrigeration is provided by spraying liquid nitrogen into the air stream at such a rate as to maintain the desired air temperature. The temperature at the center of the bean is sensed by a thermistor probe and is recorded automatically.

When a bean is placed in the experimental freezer, the temperature at the center of the tissue drops relatively rapidly at first to the freezing point, remains at this temperature for a period of time, and then falls rapidly again. The length of the temperature plateau is what we measure as the "center freezing time." It should be emphasized that this is approximately half the total time required to lower the temperature of the bean from say 40° F. to 0° F.

When the tissue damage is observed in samples of green beans frozen at different rates, there is found to be a "critical center freezing time" of about 6 to 10 minutes. Samples frozen more rapidly than this show essentially no tissue damage. With longer center freezing time, tissue damage becomes more and more extensive. With center freezing times greater than about 15 or 20 minutes there is little further increase in damage. It should be noted that the center freezing time for liquid nitrogen freezing can be of the order of 10 seconds, while the center freezing time for a belt freezer as conventionally operated is about 15 minutes.

The significance of these findings lies in the fact that liquid nitrogen freezing offers a freezing rate approximately 50 times greater times of 6 to 10 minutes, then there is no need to go to liquid nitrogen freezing.

There are alternatives to LNF which would provide center freezing times of 6 to 10 minutes or less. Proposals have been made to use liquid nitrous oxide, which boils at about -127° F, or certain of the freons. These substances appear to offer some

advantages over liquid nitrogen but because they are somewhat expensive, it would be necessary to operate the freezing equipment as a closed system, recovering the gas and reliquefying it. Both liquid and solid carbon dioxide have also been proposed for achieving very rapid freezing (8).

A more promising alternative, perhaps, is the fluidized bed freezer (1, 10). Several of these are already in commercial use in this country. This type of equipment consists of a trough with a perforated or wire mesh bottom through which refrigerated air is blown at a relatively rapid rate. The product to be frozen is introduced at one end of the trough and the individual pieces are suspended in the upward-moving air. Because each piece is surrounded by rapidly moving, refrigerated air, freezing is quite rapid and uniform. The product gradually moves down the trough and overflows a weir at the far end.

We have not yet had an opportunity to measure the center freezing time achieved in fluidized bed freezers but the manufacturers of one unit state that peas require 7 minutes total freezing time if they go into the freezer at 40° F. and out at 0° F. With a total freezing time of 7 minutes we would expect a center freezing time of the order of 4 minutes, which is substantially shorter than the critical freezing time found for green beans.

Another possible alternative to LNF is modification of the conventional belt freezer. The center freezing time need only be cut in half, that is, from about 15 minutes to about 6 to 10 minutes, in order to freeze green beans without tissue damage. This we believe could be accomplished by loading the belt less heavily, speeding it up, and providing a substantially higher velocity of air. It might also be necessary to lower the temperature of the air somewhat below the -20° F. that is commonly used today.

Summary

In summary we should like to make the following points:

(1) Liquid nitrogen freezing preserves the texture of green beans and certain other foods better than conventional quick freezing methods.

(2) We do not now have a very complete understanding of what takes place when a plant or animal tissue is frozen, or of the cause of tissue damage.

(3) A very simple histological technique to assess tissue damage is now available.

(4) LNF can give a freezing rate in green beans approximately 50 times faster than that required to avoid tissue damage.

(5) There are various alternatives to liquid nitrogen freezing which should be less costly and may have other advantages.

(6) We need to know which foods show substantially improved quality when frozen very rapidly, for example, by LNF.

(7) We need information on the critical center freezing times of all the fruits, vegetables, and other foods which show quality improvement when very rapidly frozen in order to provide a basis for the selection of the most appropriate freezing method.

References

(1) Anonymous. Food Eng. 34 (11), 60 (1962).

(2) Anonymous. Food Eng. 36 (11), 73 (1964).

(3) Anonymous. Quick Frozen Foods 27 (1), 46 (1964).

(4) Asahina, E. Contributions from the Institute of Low Temperature Science (Japan), No. 10, 83-126 (1956). (In English).

(5) Food Engineering Staff. Food Eng. 36 (1), 56 (1964).

(6) Mason, R. H. Quick Frozen Foods 24 (11), 41 (1962).

(7) Meryman, H. T. Science 124, 515 (1956).

(8) Rubin, J. Quick Frozen Foods 27 (6), 73 (1965).

(9) Taylor, H. F. Food Ind. 3, 205 (1931).

(10) Trauberman, L. Food Eng. 34 (8), 46 (1962).

(11) Tressler, D.K., and Evers, C.F. The freezing preservation of foods. 3d ed. Avi Pub. Co., Westport, Conn. (1957).

(12) Webster, R.C., Benson, E.J., and Lucas, W.H. Quick Frozen Foods 25 (5), 35 (1962).

(13) Wolford, E.R., and Brown, M.S. Food Technol. (In press).

(14) Woolrich, W.R., and Bartlett, L.H. Mech. Eng. 64, 647 (1942).

DISCUSSION

Question: In this methanol evaluation; doesn't it dissolve more than the ice? What do you think the ice solvent should be?

H. K. Burr: In the methanol procedure for preparing sections of green bean tissue, undoubtedly the methanol does dissolve some things beside the ice. Essentially it dissolves the ice out of the tissue. In fact, comparison of sections prepared by this methanol technique and by the much more elaborate histologic technique, shows that methanol is best for removing ice. In ethanol, you will get shrinkage.

Question: Have you investigated the loss in quality which you get on commercial storage of these products?

H. K. Burr: No. We are dealing, so far at least, merely with the initial quality.

Question: We froze fish back about 1930 by immersion freezing and we got the same quick freezing time, but after commercial storage for several months, a lot of that quality improvement was lost.

H. K. Burr: This is certainly one of the questions that we want to follow up because it has been suggested that during commercial storage you may lose the advantage that you gain by going to extremely rapid freezing.

Question: This is a theoretical question in regard to the nature of damage by freezing. Would it be possible to make studies of frost-resistance and winter-hardiness of plants, which vary quite widely in nature, and maybe find an answer to the question that way? In other words, why do some plants resist freezing without damage, that is, go through the winter, and other plants are very sensitive to it?

H. K. Burr: Well, work has been done in this area, and one of the references that will appear in the published proceedings is to a study made by Asahina, a Japanese who unfortunately publishes his results, in English, in a rather obscure place. What he was trying to get at was the mechanism of frost resistance in living plants. Now, our concern, of course, to this point, has been with a dead plant tissue. We have blanched the green beans so they are dead. I would say, however, that in spite of the work of Asahina and many other people, we still are pretty ignorant of the phenomena of freezing in both living and dead plant and animal tissues.

Of course, one place where they are very interested in maintaining vitality is in the freezing of blood cells, and in the freezing of semen for artificial insemination. But here you are talking about freezing rates that are far faster even than those of which I spoke -- not ten seconds, but a matter of milliseconds. You have to spray the blood in the form of fine droplets directly into liquid nitrogen, and you probably achieve center freezing times, if I can use that term, in the order of perhaps a hundredth of a second in order to maintain vitality in the cells.

QUICK-COOKING DEHYDRATED FRUITS AND VEGETABLES BY EXPLOSIVE PUFFING

by
J. Cording, Jr.
Eastern Utilization Research and Development Division
Philadelphia, Pa.

There has long been a need for a dehydration process, operable at moderate cost, applicable to relatively large pieces of fruits and vegetables, which can yield products capable of rapid reconstitution. Such products cannot be made by conventional hot air

drying methods. The reasons why are well put in the book, "Potato Processing" in the chapter on "Dehydrated Diced Potatoes" (1), from which I quote: "Piece size has a tremendous effect on drying rate. This has been a limitation in expanding the use of dehydrated foods and especially in producing products for remanufacturing uses such as in stews, salads and other recipes that normally use a relatively large piece. An increase in thickness of piece size from 1/8 inch to 1/2 inch will reduce dehydrator capacity by about 90 percent." Even if large pieces could be made by conventional hot air drying they would require extremely long time for reconstitution.

As a means of solving this problem we thought it might be possible to modify temporarily the internal structure of a piece of fruit or vegetable so that drying and reconstitution could be accomplished rapidly. Obviously, these structure changes would have to be such that the texture of the reconstituted product would be as similar as possible to that of the fresh product. Could this be done by explosive puffing?

The puffing of cereals has been done for half a century and many of you have no doubt seen on television antique cannons with puffed cereals spewing from their muzzles while a white-uniformed foreman repeatedly shouts "fire"--all to the accompaniment of Tchaikovsky's 1812 Symphony. This is not quite what we had in mind.

In the puffing of cereals the object is to permanently alter the structure of the grain, increasing its volume sometimes as much as 15-fold, yielding a product with little resemblance to the starting material. This is accomplished using grain of low moisture content and employing pressures of 200 pounds or more per square inch during puffing. In contrast, if our idea was to be successful the dehydrated pieces on reconstitution would have to come back to the same size, shape, and if possible, the same texture as freshly cooked pieces of corresponding size.

To try this we purchased a small cereal puffing gun. It was of heavy cast iron, rough on the inside and had a primitive closing mechanism. It was heated externally with a gas flame and when sufficient pressure had been obtained it was fired by hitting the latch with a hammer. Even with this crude beginning we were able to show that some unique dehydrated products could be made. For instance (by puffing) 3/8-inch dehydrated carrot dice could be made which were ready for eating in 5 minutes boiling instead of 45 minutes customarily needed for conventional hot air dried pieces of the same size.

The basic principle of the process as finally worked out is quite simple. It merely entails partially drying the pieces generally to about 30 percent moisture, charging them into a gun where they are brought quickly to a temperature which superheats the contained moisture in the piece above its atmospheric boiling point. This is possible because of the pressure which develops in the gun during heating. When the gun is fired, a small percentage of the moisture is instantly vaporized, creating a porous structure. This enables the final stages of drying to be carried out in a conventional way with hot air but at a greatly accelerated rate. Moreover, final moistures lower then those feasible with unpuffed pieces can be easily obtained. Most important of all the dried pieces take up hot water very quickly and are ready for eating in 2 to 5 minutes boiling.

For each fruit or vegetable there is an optimum range of moisture in the piece and an optimum puffing pressure. Let us consider carrots for example. Figure 1 shows the range of moisture in the piece and the puffing pressures which yield good products. Any combination of piece moisture and pressure within the encircled area is satisfactory. Pressure above about 42 pounds per square inch either scorches the pieces if moisture is low or blows them to bits if moisture is high. Below about 25 pounds per square inch no puffing occurs regardless of moisture content. In practice we would operate at about 30 pounds per square inch and all pieces between 25 and 55 percent moisture would puff satisfactorily. At moistures to the left of the dotted line little collapse of pieces after puffing was noted. Actually closer control of moisture is both desirable and feasible. Twenty to 30 percent is optimum.

The contrast between explosion-puffed dehydrated pieces and those conventionally dried is apparent in figure 2. All these pieces have been simmered 5 minutes. Those on the left (a) are fresh carrots--still not soft enough to eat. Those in the middle (b)

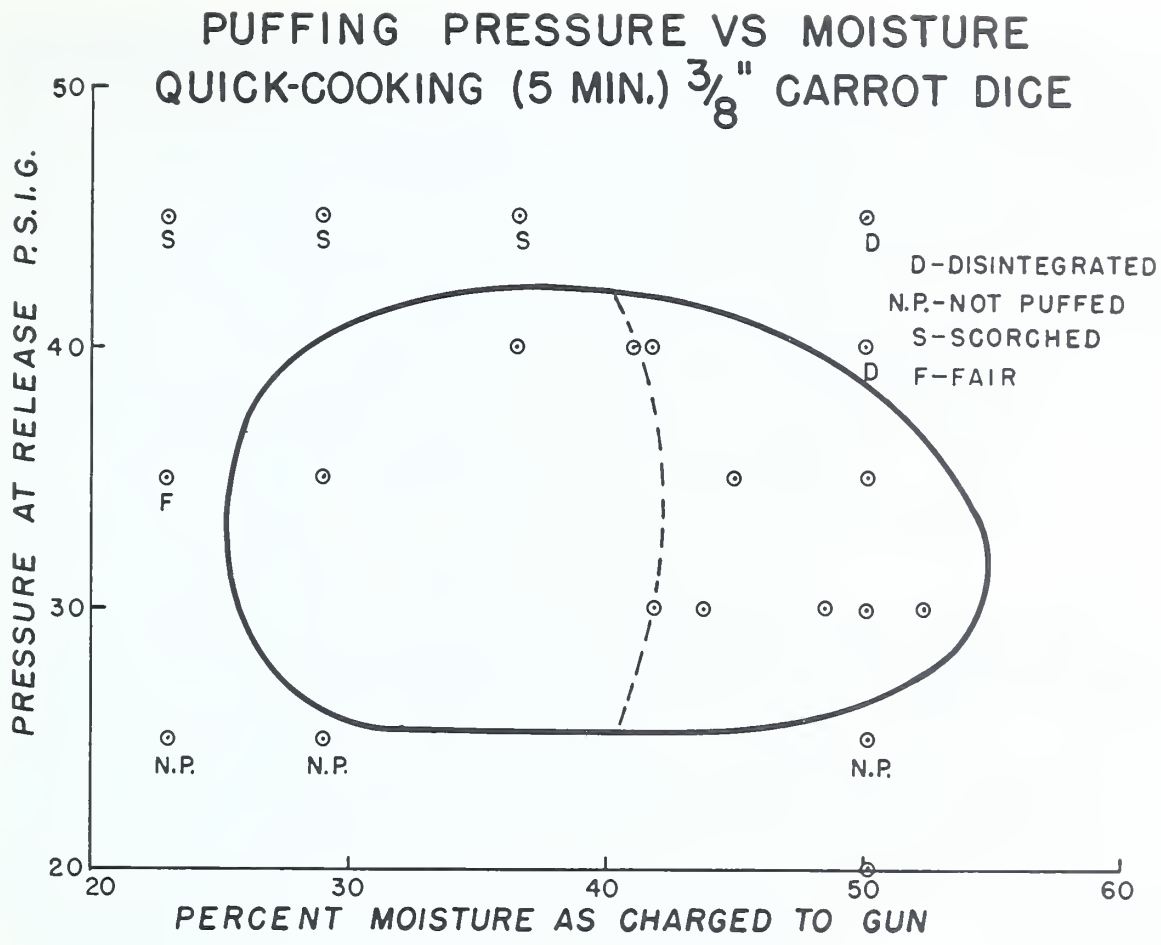

Figure 1.--Puffing pressure vs. moisture content, 3/8" carrot dice.

have been conventionally dried. It is apparent that they have barely begun to pick up water; another 40 minutes would be required to complete their cooking. Samples labeled (c) were explosion puffed and dehydrated. They have regained their shape and size and are ready to eat.

Why explosion-puffed dehydrated pieces rehydrate so rapidly is apparent from figure 3. This shows cross sections of explosion puffed (on the left) and regular dehydrated 3/8-inch potato dice on the right. On rehydration the explosion-puffed material swells and the holes disappear, yielding products with the same appearance and mouth feel as the freshly cooked vegetable.

While we are speaking of potatoes we can look at some explosion-puffed slices (figure 4). Again the explosion-puffed slices are on the left. Equal amounts are in each pile, so you can see they are no more bulky than the now familiar product on the market. They permit making scalloped or au gratin potatoes in 15 minutes' baking instead of the usual 45 minutes to one hour.

Finally (in figure 5) we see the long-sought stew chunks. These were 1-1/2 in. x 1-1/2 in. x 3/4 in. Reading the rows left to right, we have in the first row, pieces dried to about 25 percent moisture; in the center row the pieces are puffed and dried; and finally we see them in the last row, ready to eat after only 5 minutes' cooking.

There was no suitable gun available for puffing dehydrated fruits and vegetables. We had therefore, to design our own. It was built by a Philadelphia firm and has proven highly satisfactory. Detailed construction drawings are available and several companies are having units made for commercial use. It has a capacity (with carrots for instance) of ten 20-pound charges per hour; somewhat less perhaps for fruits. It is shown in figure 6 in the operating position.

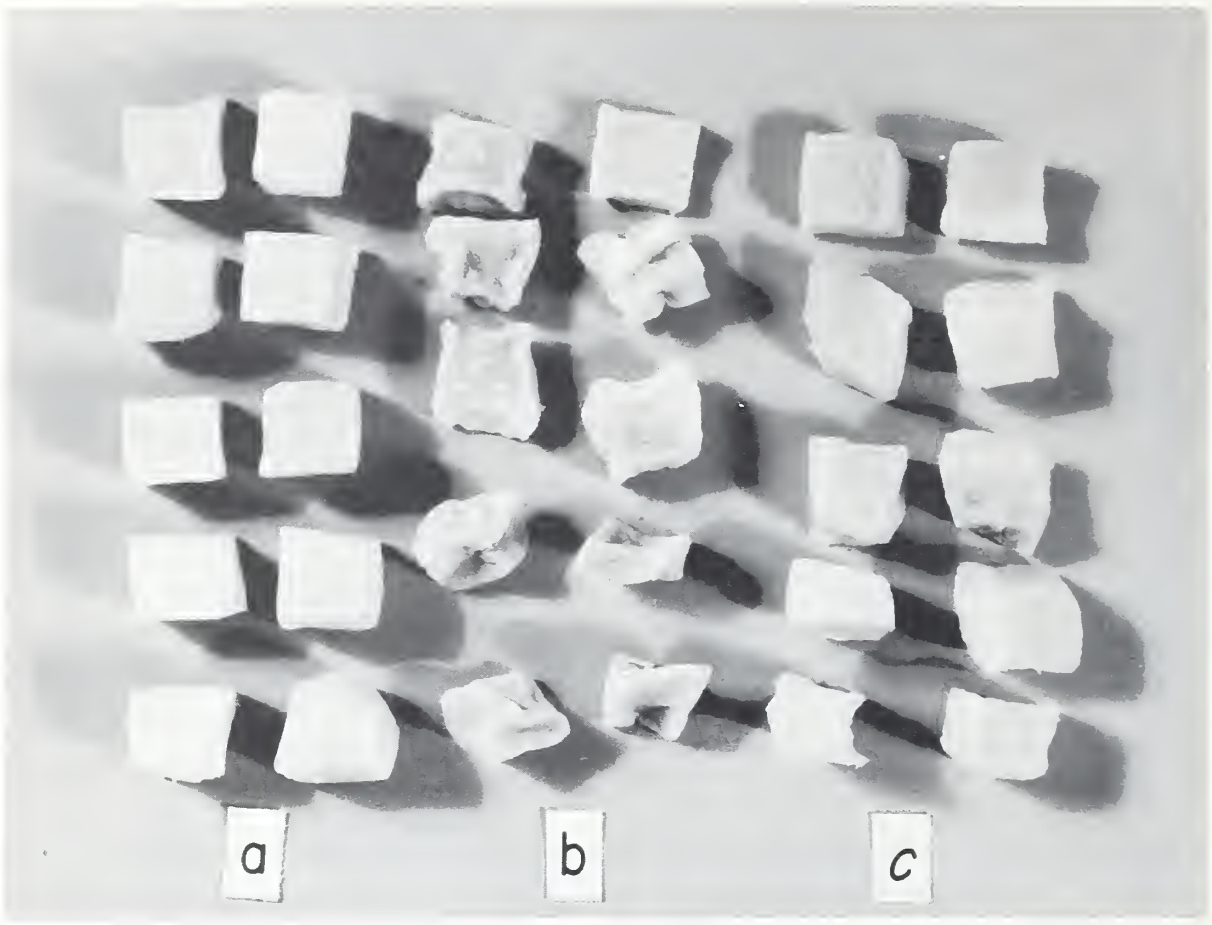

Figure 2.--Carrot Dice: Fresh (a); conventionally air dried (b); and explosion puffed (c). All simmered 5 min. in water.

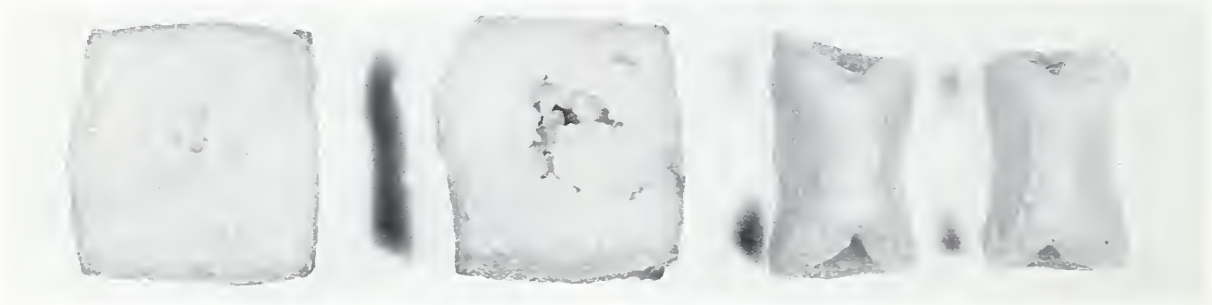

Figure 3.--Cross sections 3/8" potato dice. Explosion puffed (left); conventionally air dried (right).

Figure 4.–Explosion puffed (left) and conventionally hot air dried (right) potato slices.

Figure 5.–Potato chunks (¾'' x 1½'' x 1½''). Before puffing, 25% moisture (left); after puffing and final drying (center); simmered 5 min. (right).

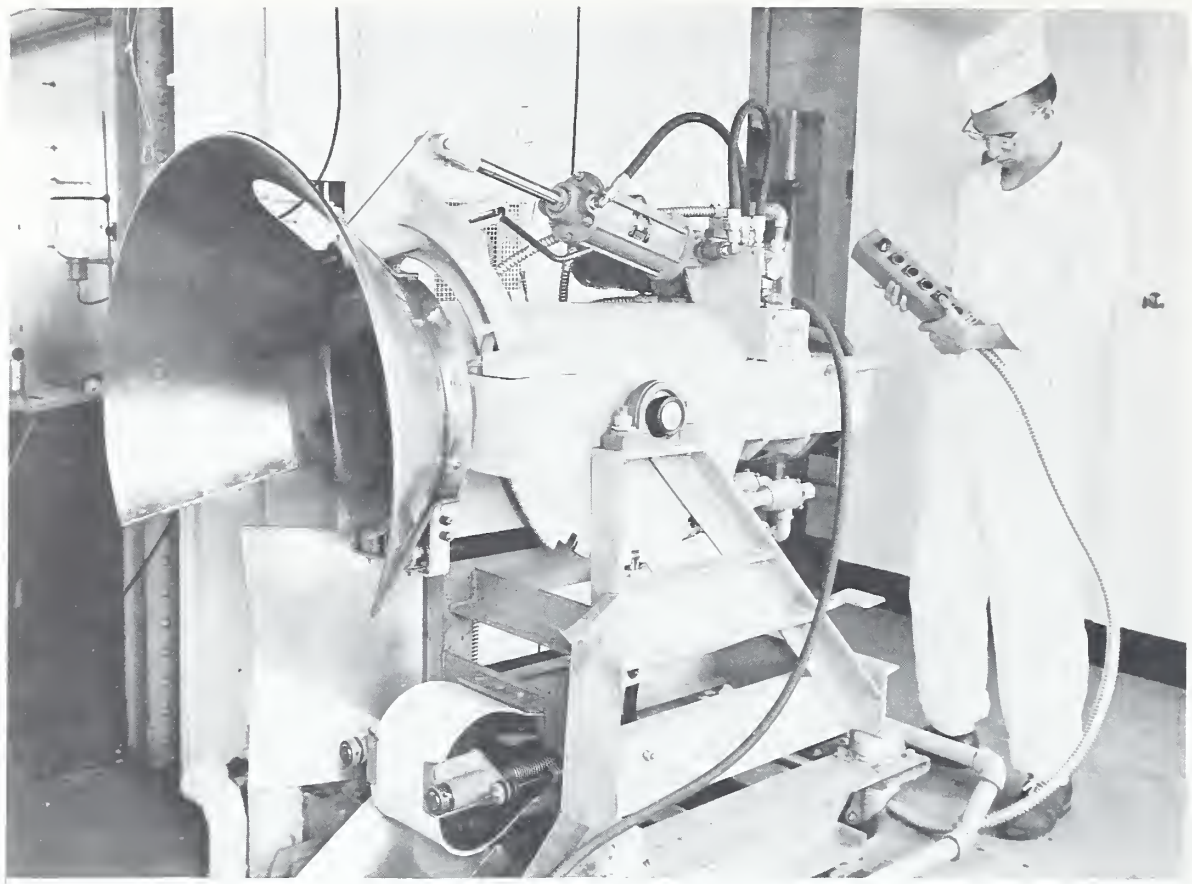

Figure 6.–EURDD puffing gun in operating position rotating with charge in.

The stainless steel rotating cylinder of the gun proper is not visible as it is housed within the shell. The piston on top is the compressed air mechanism for closing and tripping the lid. The pipes underneath are gas burners used to preheat the charge and to maintain a sufficiently high wall temperature to prevent condensation of the injected steam. The superheated steam is introduced at the back of the gun through a rotary joint. The operator holds the pushbutton control station from which we start or stop gun rotation and open or close the lid.

Operation of the gun is as follows: By the gas flame underneath, the gun wall is brought to the desired temperature of about 350° F., which is measured by a sliding thermocouple on its surface. The gun is then opened, tilted 45 degrees upward from the horizontal and charged. The lid is closed and locked. It is then tilted to the horizontal position and rotation is started. With the gas burners lighted the charge is tumbled for a minute and a half. This forewarms the pieces so that condensation will not take place when the superheated steam is injected. With the burners still lighted, steam at about 500° F. is admitted and within less than a minute the desired pressure of 35 pounds per square inch in the gun is reached. This is held for 1/2 minute to ensure superheating the contained moisture in each piece. The gun is then tilted to firing position, the gates to the collection chute are closed, the burners extinguished and the gun is fired. There is a loud bang, a burst of steam and the charge is blown into a 30-foot collection chute, from which it is removed for final drying.

The next few figures afford a closer look at the gun.

Figure 7. Here the gun is being charged.

Figure 8. This is a close look at the locking mechanism. It is toggle, unique in that the greater the pressure, the tighter it locks.

Figure 9. The gates are now closed and the gun points directly into the collection chute preparatory for firing.

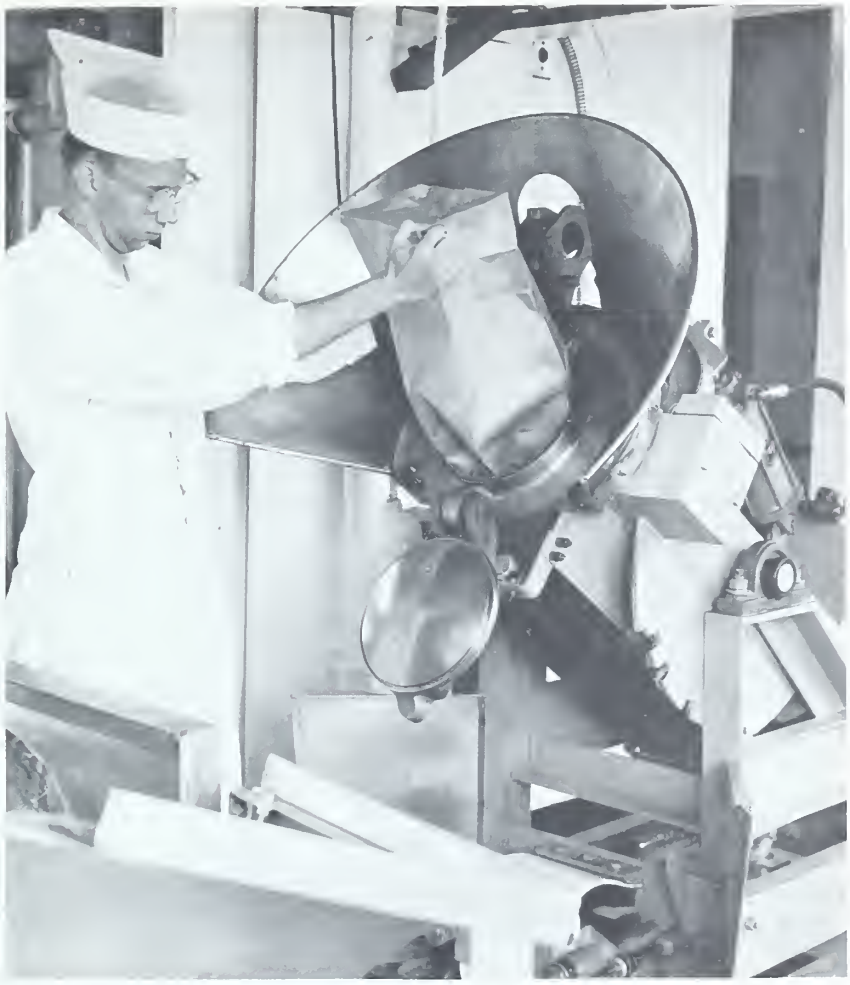

Figure 7.–EURDD gun charging position.

The attributes of explosion-puffed dehydrated foods are all on the plus side compared to conventionally dried products, with one exception. They are somewhat more bulky and hence cost more to package. This has now been overcome in the case of carrot dice. In fact, we have made explosion-puffed carrot dice that are actually less bulky than conventionally dried pieces of the same initial size. Like so many advances in technology, this was the consequence of an accidental discovery. With the more efficient gun, larger charges became possible and these exploded with such violence that it was difficult to avoid collapsing them again in the collection chute. Although the collapsed pieces looked strange, it was found that they rehydrated just as quickly as the uncollapsed ones. Why not then deliberately collapse them and enjoy the benefits of reduced bulk? This has proven simple and practical.

The puffed dice are still moist and thermoplastic as they come from the gun. At this stage they can be passed between rollers set as close as 1/32 of an inch. This gives flattened shapes which, when dried, have a bulk density between 28 and 30 pounds per cubic foot as contrasted to about 20 pounds per cubic foot for the puffed pieces dried without squeezing. The squeezed pieces actually have a higher bulk density than conventionally hot air dried pieces of the same initial size and shape. It is hard to believe that these compressed dice rehydrate just as quickly as the uncompressed ones and fully regain their cubical shape in 5 minutes' simmering. They do, however. It appears that the pores formed in puffing are temporarily collapsed by squeezing but rapidly reappear when the pieces are put in boiling water.

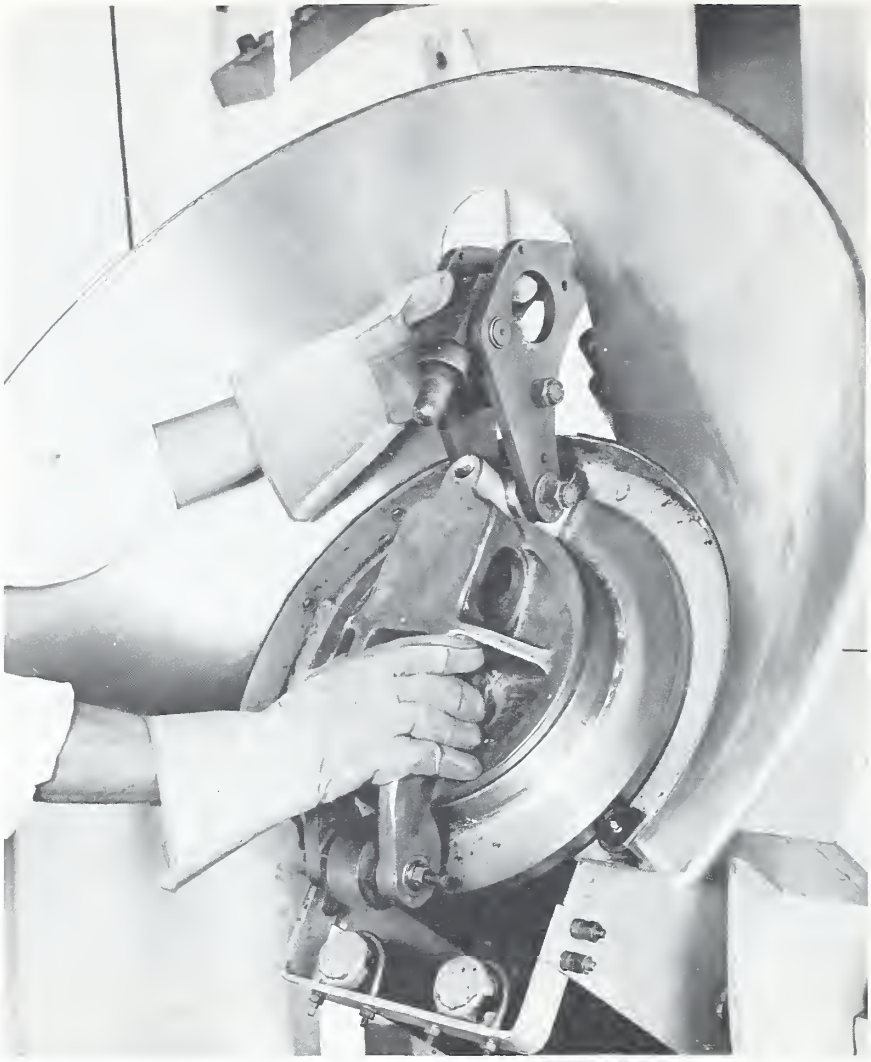

Figure 8.—EURDD gun showing lid and toggle closure.

The process has thus far been successfully applied to vegetables such as potatoes, carrots, beets, sweet potatoes, rutabagas and apples and blueberries as well.

Explosion-puffed apple segments (figure 10) can be readied for a pie filling by 5 minutes' boiling in contrast to at least 5 hours' soaking customarily employed with other types of dehydrated apples; or, the explosion-puffed dried pieces can be crushed to yield a truly instant applesauce. The sauce has the appearance and grain of the familiar canned product but possesses more the flavor of a baked apple than a stewed apple. We are currently cooperating with the Musselman Division of the Pet Milk Company on a large market test with the instant applesauce.

What do explosion-puffed dehydrated products cost? Our estimates indicate that carrots can be puffed to sell at a price no more than about 15 percent higher than that of conventionally hot air dried pieces of the same size. This is, of course, vastly cheaper than freeze drying.

What about nutritive value? We have recently shown that in spite of the fairly drastic treatment in explosion puffing, the carotene content of reconstituted explosion puffed carrots is higher than that of the same carrots reconstituted after conventional drying.

What are the commercial prospects? One large company in California is offering explosion-puffed dehydrated carrots in

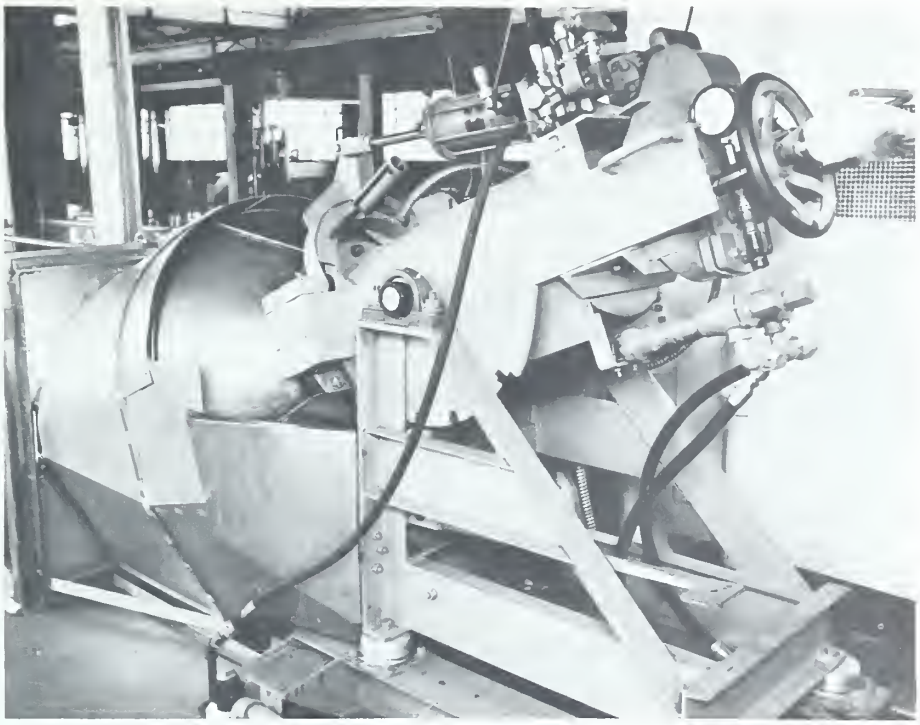

Figure 9.–EURDD gun firing position.

Figure 10.–Explosion puffed apple products rehydrated.

100-ton lots made by what is reported to be a modification of our basic process. Guns built from our designs are in operation now in Japan and the American manufacturer who made our unit has received orders from two companies in Germany. We have no way of knowing how many other companies here and abroad are building guns from our designs and experimenting with the process.

Although batch guns are entirely feasible commercially (the cereal people are still using them), we have not overlooked the possibility of a continuous puffer. In fact, we have designed one which is now being built.

I may be somewhat subjective in my viewpoint but I believe explosion puffing is the biggest advance in dehydration since freeze drying and will find wide use with other fruits and vegetables as well as those already tested.

Reference

1. Kueneman, R.W., "Dehydrated Diced Potatoes," Chapter 14, p. 365, in "Potato Processing" by Taulburt, W. F., and Smith O. The Avi Publishing Co., Westport, Conn. (1959).

COMPARISON OF FOOD DEHYDRATION TECHNIQUES

by
E. Seltzer
T. J. Lipton, Inc.
Englewood Cliffs, N. J.

Most of us here today are food scientists with some specialty in food technology. As such, we have all at one time or another had a hand in drying some kind of food, perhaps only for analytical moisture determinations. But we remember, some of us only vaguely, that drying means removal of water or other liquids from gases, liquids or solids; and dehydration usually is accepted to mean drying of foods by artificial thermal means - in contradistinction to natural means as by sun or wind (solar evaporation, e.g., salt, prunes, raisins, apricots). By our definition we exclude mechanical methods such as filtration, screening, pressing, centrifuging and settling. Evaporation with heat differs from our arbitrary definition of dehydration mainly in the kind of equipment used and in the fact that it involves removal of larger amounts of water than in dehydration.

Two physical processes are involved in dehydration (drying):

1. transfer of heat energy to evaporate water, and
2. transfer of water mass as vapor and internal water.

The heat transfer is by conduction, convection and radiation - and sometimes, though rarely, by electrical methods such as high frequency electrical induction, e.g., dielectric heating.

If this were a university lecture or an Institute of Food Technologists "short course", I would now proceed to deliver a systematic presentation of simple drying theory and then a classification of drying methods and machines in accordance with the patterns chosen by recognized authorities. For example, Marshall and Friedman (2) classify dryers by the method of heat transfer:

(1) Direct, which is usually by convection, batch or continuous, where hot gases supply heat and carry away water vapor.
(2) Indirect, which is usually by conduction, batch or continuous, where heat is transferred through a retaining wall and the water vapor is removed independently of the heating medium.
(3) Radiant (or Infrared), $\rightleftharpoons\bigcirc\rightleftharpoons R^4$ (degrees Rankine or Absolute). With these classes of dryers, by method of heat transfer, I could now proceed to give a two hour presentation of charts, photographs and drawings which could be educational for some and a review for others. At any rate, it would usurp a whole session here and could be a sterile experience for those of you who are not novices to food dehydration.

Another less painful or less didactic approach to dryer classification is to take the

three dryer classes chosen by Brown, Van Arsdel and Lowe (1). Their skeletal classification is for three types of dryers:

(1) Air convection dryers
(2) Vacuum dryers, and
(3) Drum or roll dryers.

Now, if we need to choose a dryer or a method of drying we can narrow the choice by whether we are to dry a food from the liquid state or the solid state. In the case of liquids, the choice becomes narrower in accordance with whether we are dealing with thin fluids, viscous or plastic fluids, or foams. When drying solids, the choice of method or equipment is narrowed by the physical condition, whether the food consists of chunks, particles or powder.

Chances are that when we are on the job (not in the university) we would not go through a systematic classification and we would jump, one at a time, to hunches or to what we have on hand in the pilot plant or factory. Or we may have to be good soldiers and pamper the boss who just discovered a panacea in the Wall St. Journal or Readers Digest. Well today we will pretend we are righteous scientists and we will check out the classifications, such as the one by Van Arsdel and his co-authors (1) or follow some technical rationale. A young colleague of mine, M. Hertzendorf, who has a systematic, uncluttered mind, thinks in terms of "Evolution of Drying Techniques." He draws simple diagrams, one of which would be a pattern for logical investigation of liquid drying as shown in figure 1.

In another scheme for "Evolution of Drying Techniques", he conceives of the logical path for drying solids as shown in figure 2.

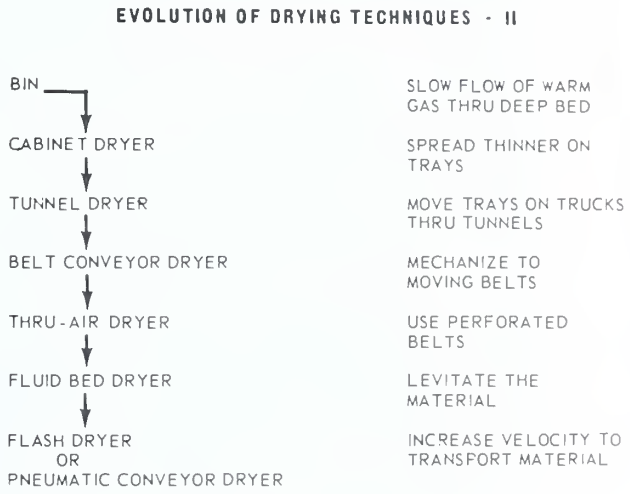

Figure 2.–Evolution of drying techniques – II

I should like now to select some provocative new ideas in dehydration and to explore their significance for the future. I'll draw examples from each of the Van Arsdel classes of dryers:

A. Air Convection Dryers:
Spray dryers - Gas injection devices

patents by Heath and Washburn - 1922
U. S. Patent 1,406,381
Reich and Johnston - 1957
U. S. Patent 2,788,276
paper by Hanrahan and Webb - 1961
Food Eng'g 33, No. 8, 37-38

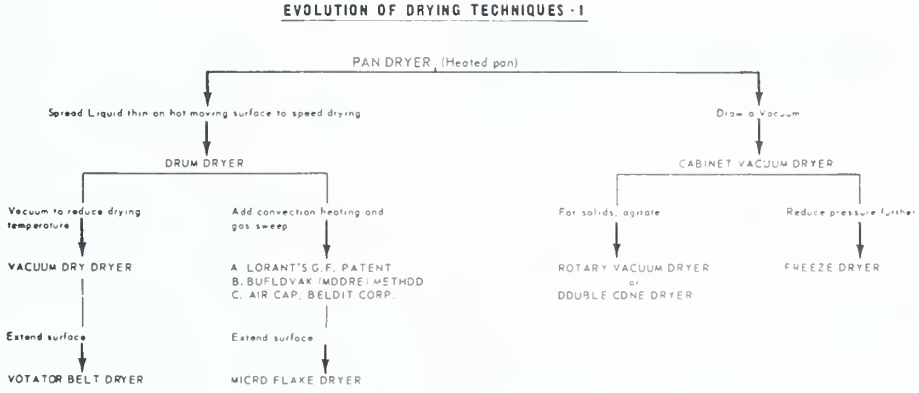

Figure 1.–Evolution of drying techniques – I

Effects on bulk density, dryability, dryer design

Agglomeration techniques
Peebles: skim milk
Gruber: coffee

Birs Dryer - "No Heat" Spray Drying Plant (figure 3)

1. IDIT - Siena, Italy 50' diam. x 220' ht.
2. Unitroc Ltd., Burgdorf, Switzerland

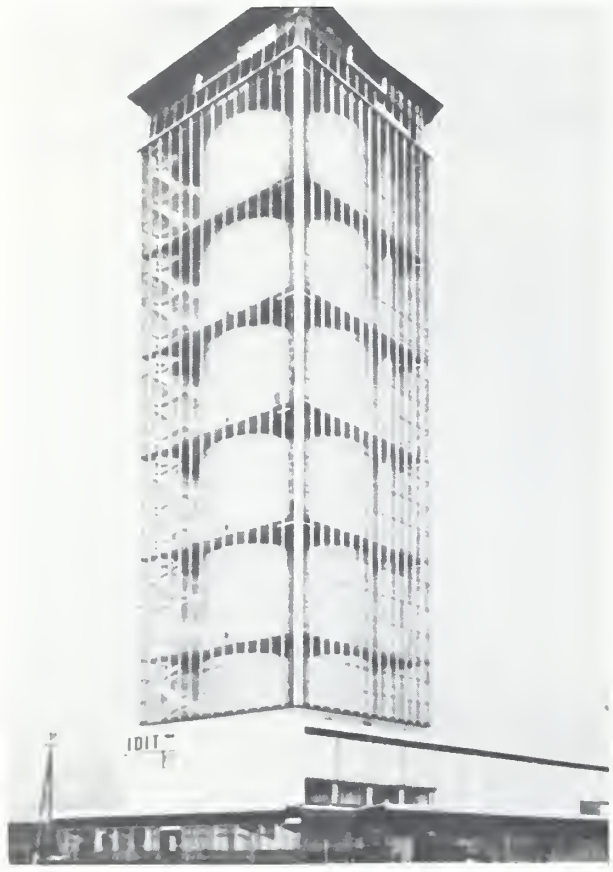

Figure 3.--Birs spray dryer

A. M. F. Microflake Dryer - This dryer illustrated in figure 4, could be classified here under air convection or later under "drum dryer". Good mass transfer through foam.

Springdale, Conn. - Tobacco sheet, foods - Foam with Tween-mos 0.7% or sucrose monopalmitate 0.2%. 22-32% solids in feed.

Inject N_2 with Oakes Mixer at 40-45 psi - Foam density about 0.55 g/cc and as low as 0.29 g/cc.

Steam chest 150-210° F.
Air Oven, 3 stages (200, 170, 150° F.)
Foam Film thickness 0.01 - 0.04 in.
Air temp. above belt: 125° F. - Ambient - 175° F. - Ambient
East Windsor plant: 100 ft. long x 24 ft. wide
Stamford plant: 40 ft. long x 8 in. wide
Product temp. maximum 170° F.

Possible applications: Tomato, tea, coffee, food pastes, fruit purees.

Lipton Granular Food Dryer - This dryer is adequately depicted in figures 5 and 6.

Vacuum Dryers

Figures 7 through 12 display various types of vacuum dryers including:

Freeze Dryers: "Sec" Tray Dryer - freezing in dryer chamber, double wall principle, with vac. between.
Vertical tubular types: Inside tubes:
Seffinga - showing design, filling, discharging.

Outside tubes: Mitchell Eng'g Design (Edwards High Vac. (not shown) Eng'g) Terence Rowe

Vacuum Belt Dryer: Girdler Votator (formerly Chain Belt)

Drum and Roll Dryers: are described in figures 13 through 16. These include standard 2-roll dryer, single roll with planetary rolls, (a) pilot plant model, (b) potato dryer in use, Beloit Air Cap Dryer.

Future Progress: Progress in food dehydration during the next quarter century is expected to consist primarily in elaboration and refinement of existing methods as consumer markets expand through fulfillment of needs for preservation, quality and convenience. Broad, simple, universal processes, analogous to freezing for frozen foods, though desirable seem technically implausible in the future of food dehydration. Just as today each drying method is limited to groups of special foods, more dryers will appear, each rather specific to a single food or narrow range of foods. New methods of dehydration are expected to be developed more and more specifically for individual food items - virtually a custom method for each foods. (3)

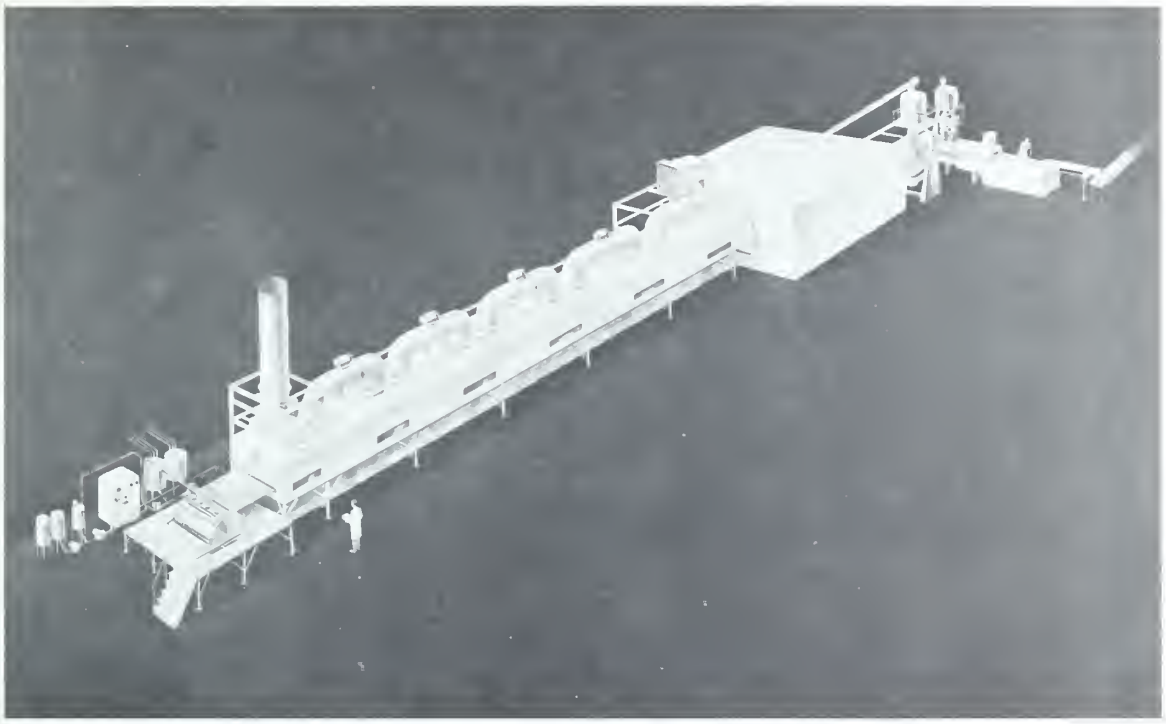

Figure 4.–A.M.F. Microflake dryer (Photographs furnished through courtesy of the American Machine & Foundry Co.)

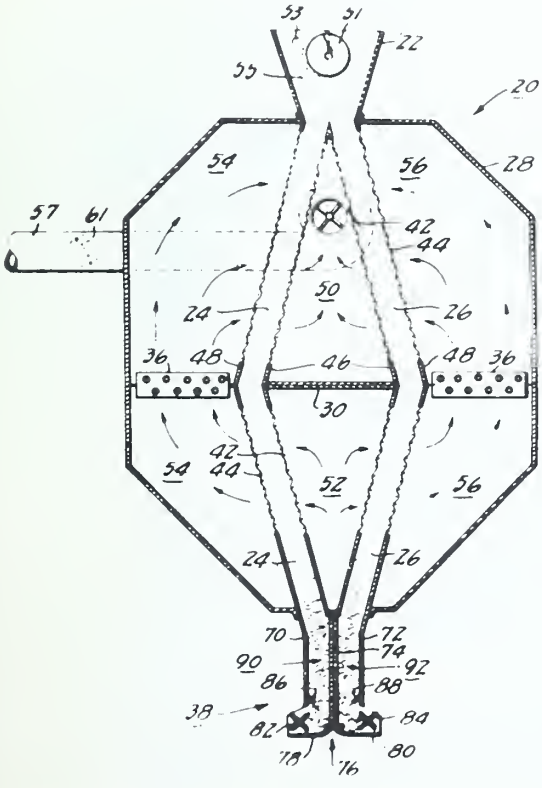

Figure 5.--Cross-section of Lipton granular food dryer.

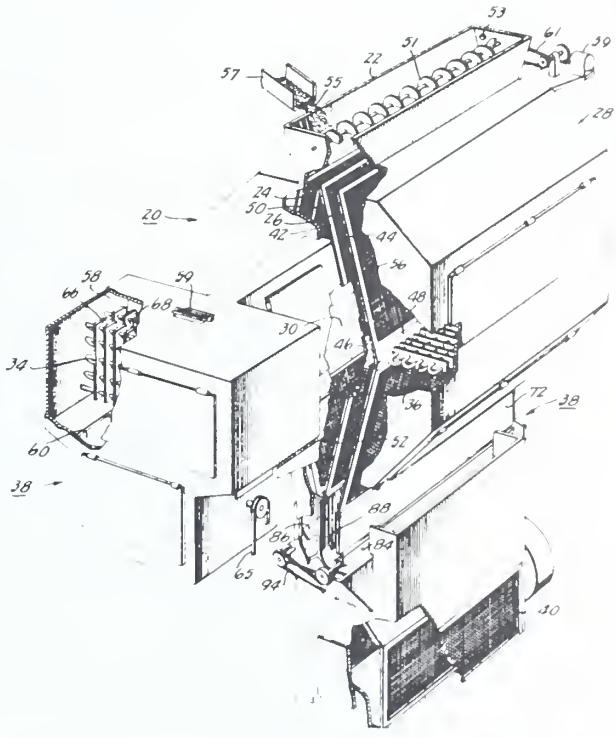

Figure 6.--Lipton granular food dryer (continuous).

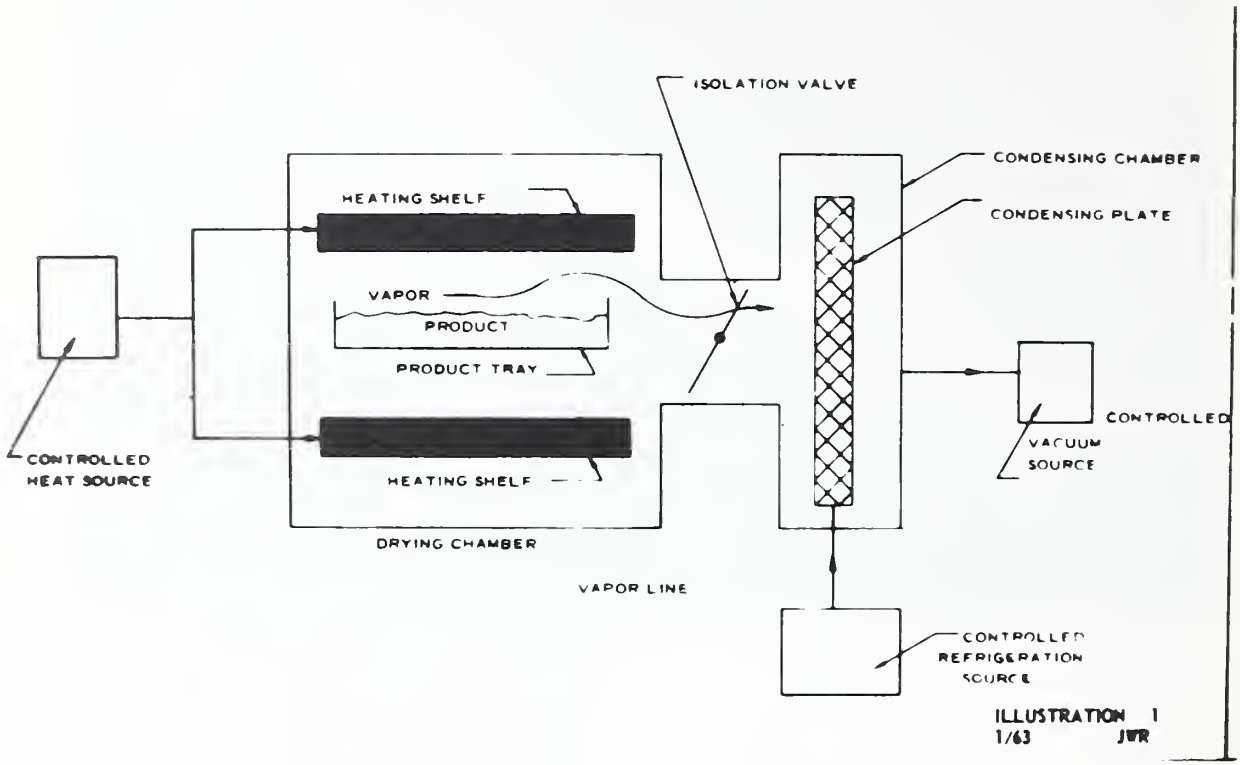

Figure 7.—"Radiation" freeze-dryer

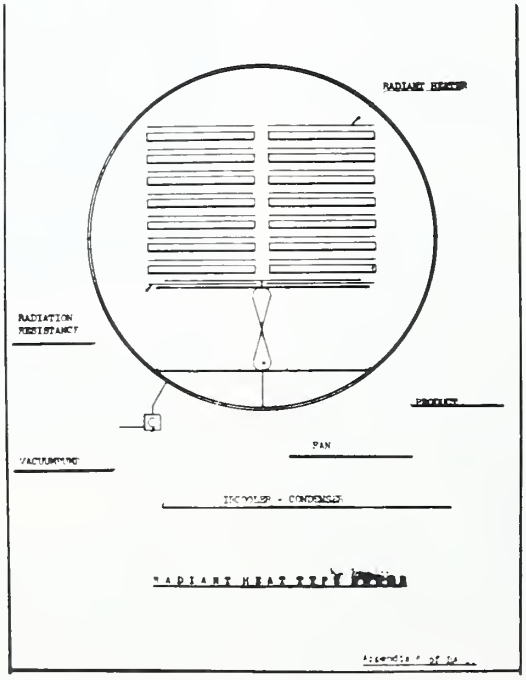

Figure 8.—Radiant heat type dryer.

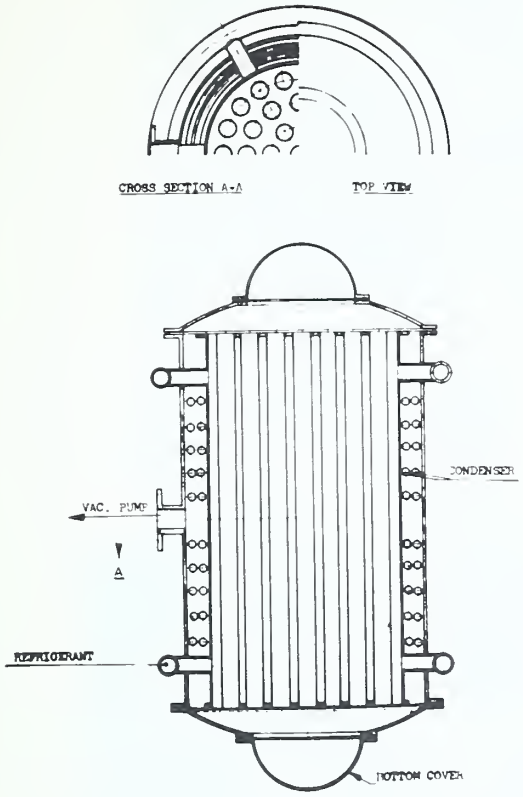

Figure 9.–Vertical bundle tube dryer (design).

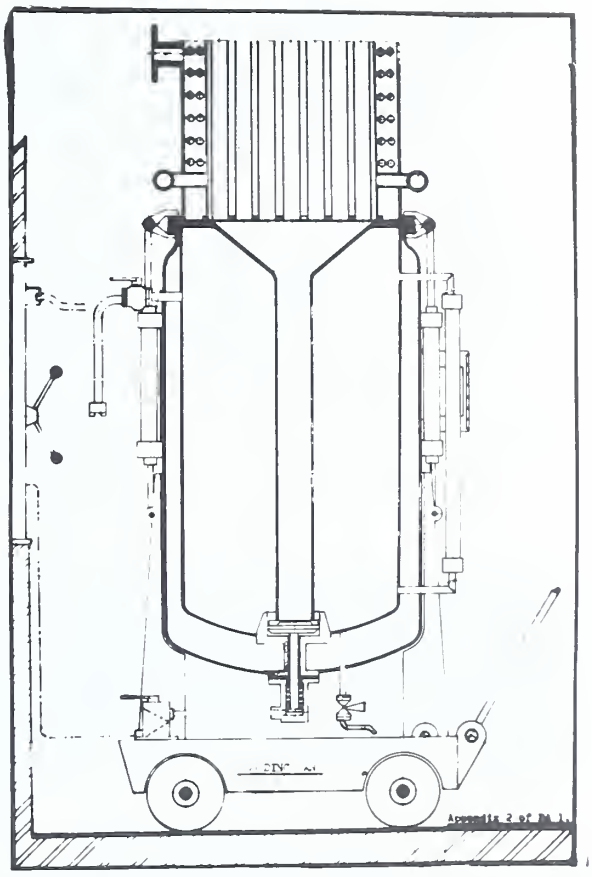

Figure 10.–Vertical bundle tube dryer (filling).

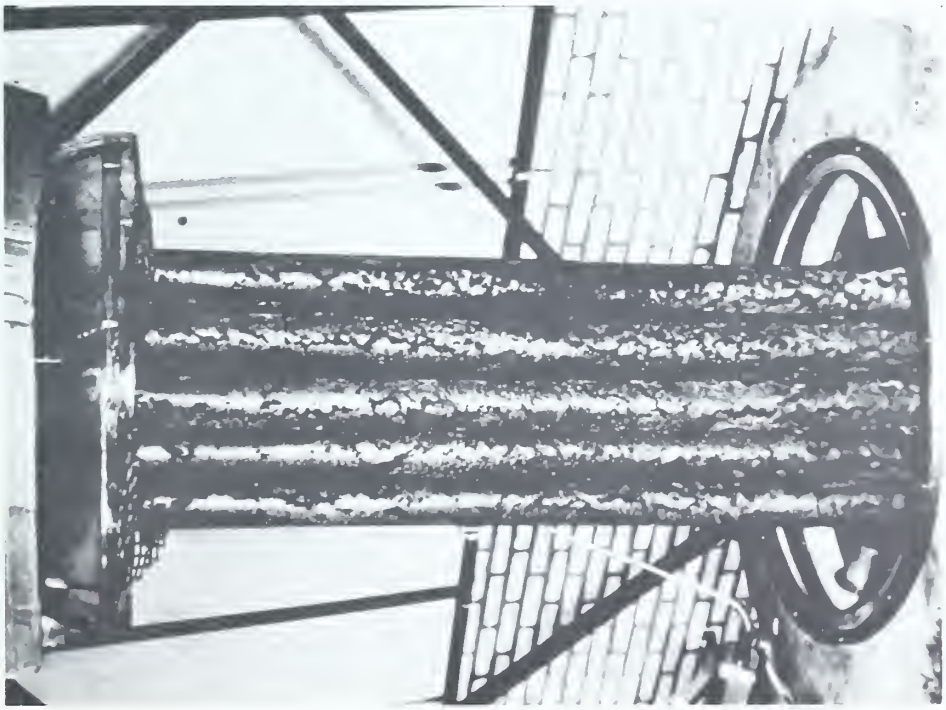

Figure 11.–Vertical bundle tube dryer (discharging)

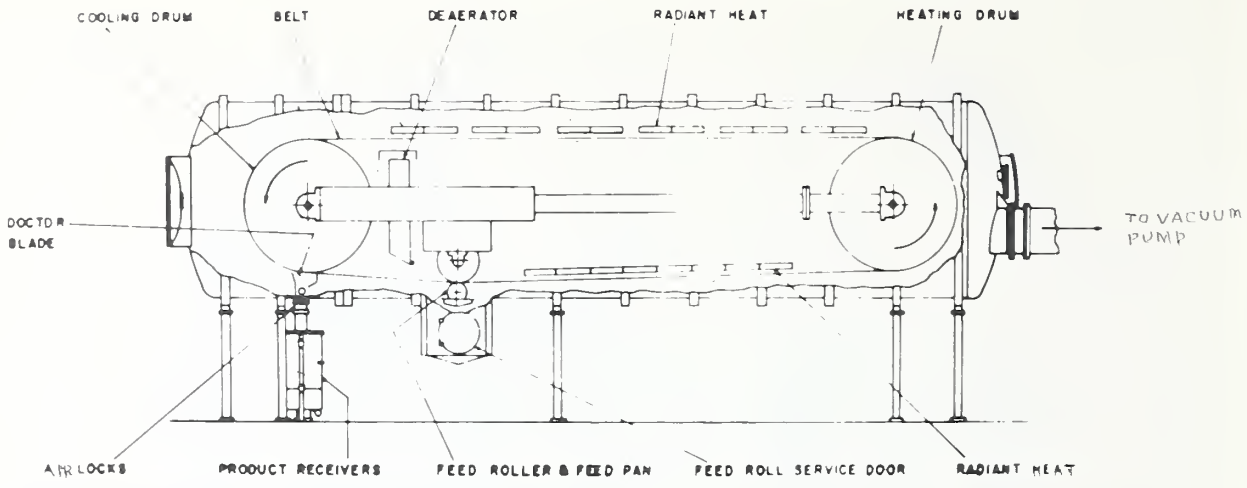

Figure 12.—Chain belt dryer

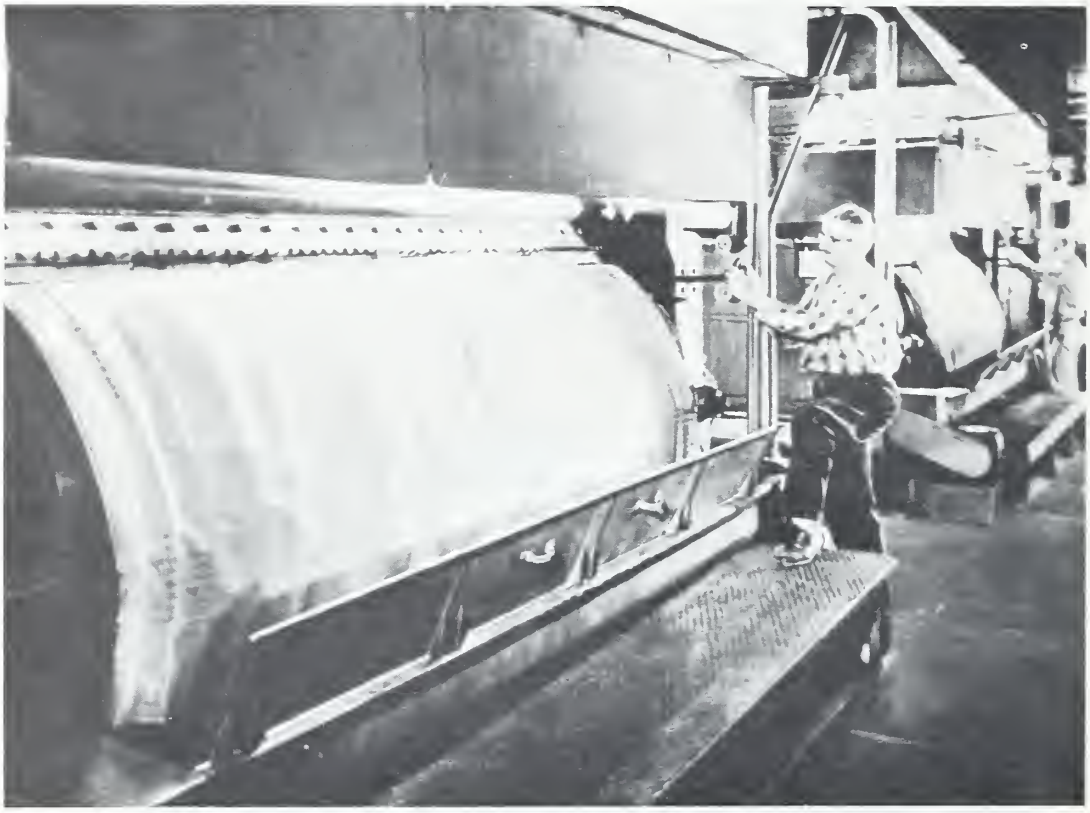

Figure 13.—F2 double drum dryer.

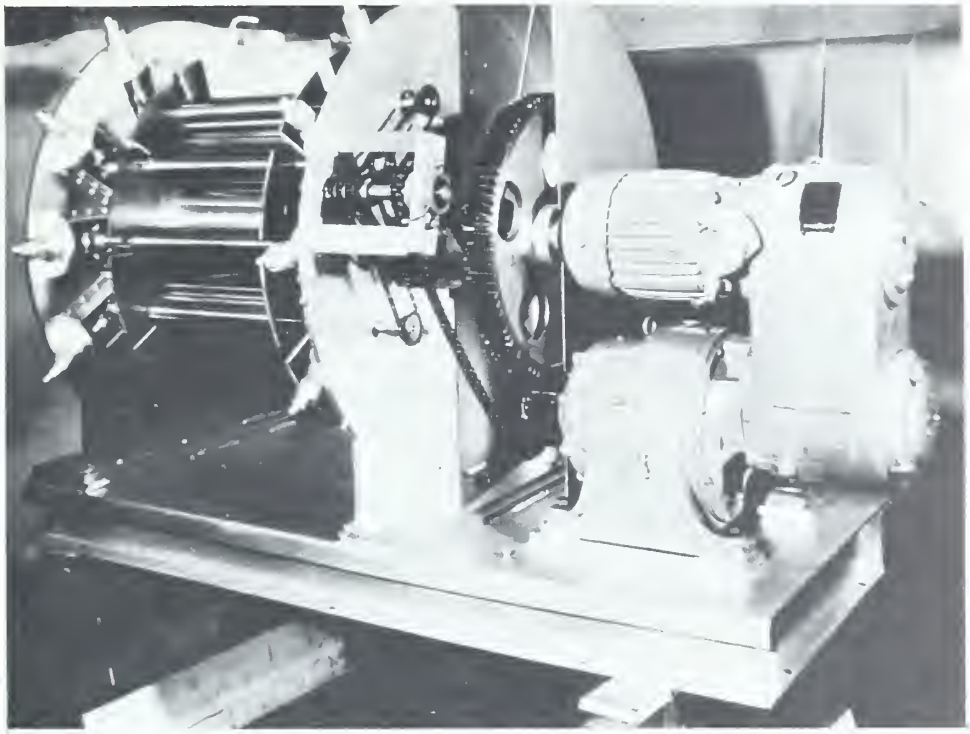

Figure Figure 14.–Pilot model single roll dryer

Figure 15.–Single roll potato dryer

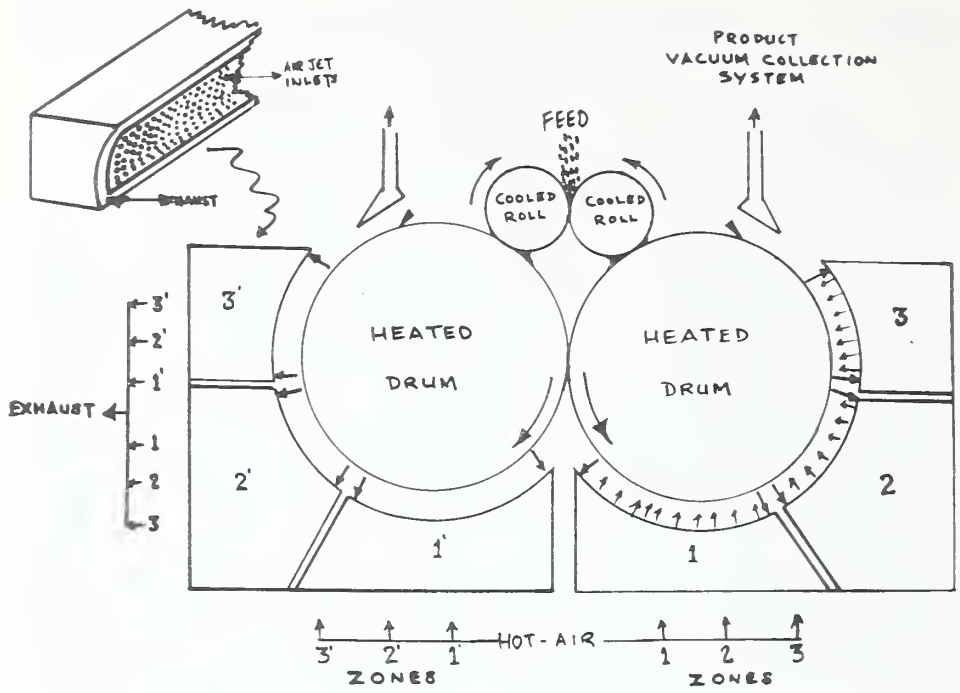

Figure 16.--Beloit "Air-Cap" Dryer

References

(1) Brown, A.H., Van Arsdel, W.B., and Lowe, E. 1964. "Drying Methods and Driers," in the text "Food Dehydration," by Van Arsdel, W.B. and Copley, M.J., Vol. II, Chapter 11. Avi Publishing Co., Inc., Westport, Conn.

(2) Marshall, W.R., Jr., and Friedman, S.J. 1950. "Perry's Chemical Engineers Handbook." Third Edition. McGraw Hill, New York, New York, pp. 799-884.

(3) Selzer, E. 1964. "Progress in Food Dehydration 1939-1964." Food Technology 18(9): 117-120.

FOURTH SESSION: Chairman, L. E. Hawkins, Oklahoma Agricultural Experiment Station

HIGH-TEMPERATURE-SHORT-TIME (HTST) STERILIZATION OF FOODS AND ASEPTIC CANNING METHODS

by
W. M. Martin
Consultant
San Mateo, California

The improvement in quality of foods sterilized by quick high-temperature processes as compared with foods sterilized by the prolonged heat treatment used in conventional canning methods was first demonstrated by Dr. C. Olin Ball over thirty years ago (1). This discovery led to the invention and development of the first commercial aseptic canning process by Dr. Ball and his associates in the Research Department of the American Can Company at Maywood, Illinois during the period of about 1925 to 1935 (2, 3). The first commercial installation of the new process, designated as the HCF (heat-cool-fill) process by Dr. Ball, was used in canning a milk product at production speeds in the range of 200-250 6-ounce cans per minute.

In this brief recognition and acknowledgement of Dr. Ball's invention and development

of the first commercial aseptic canning process, I should like to point out that these developments were the direct outgrowth of his earlier work, in which he made a thorough study of the problems involved in heat penetration and sterilization of various types of foods. From his mathematical analysis of the data accumulated in those early experiments, Dr. Ball also gave the canning industry a much needed method for evaluating the sterilization value (Fo) of heat processes over a wide range of temperatures (2).

Dr. Ball's important work in this field is recognized among bacteriologists and food scientists all over the world and needs no further comment in this discussion, except to say that this early work was the sound foundation on which rests our present knowledge of food sterilization in all its ramifications.

Now, let us get directly into the subject about which I have been invited to talk - by answering the "Why" and "How" questions which I am sure have arisen in your minds concerning quick high-temperature sterilization of foods and aseptic canning methods in general.

First. Why use the quick high-temperature sterilization method instead of the slow low-temperature heat treatments such as are used in conventional "in-can" sterilization methods?

There are two answers to this question. One is that it is possible to sterilize foods by a quick high-temperature heat treatment with minimum change or degradation in the flavor, color, vitamins and physical properties of the food constituents themselves, and the other is that the equipment system embodying the quick high-temperature processing principles lends itself to continuous high-speed operation under automatic instrument control to a greater degree than is possible by conventional "in-can" sterilization methods.

How is this possible? The answer to this question will be most easily understood by considering the effects of temperature and time in the destruction of heat resistant bacterial spores in relation to the chemical changes which affect the flavor, color, vitamins, and physical texture of the food constituents during the sterilizing heat treatment.

The relation of temperature and time to the sterilization value of heat processes in the higher temperature range, as shown by the Ball formula (4) is as follows:

$$Fo = \frac{S}{60} \times 10^{x}$$

Where $x = \frac{T - 250}{Z}$

S = Time in seconds during which product is held at process temperature T.

T = Temperature in °F. of product during process time S.

Z = Slope of thermal death-time curve in °F., which for most of the common low-acid food products has been found to be 18° F.

In the above formula, 250° F. is taken as a standard reference temperature, and the sterilization value, Fo, is expressed as time in minutes at this temperature. The sterilization values (Fo) are thus expressed on a comparable basis irrespective of actual process temperature.

To illustrate the practical significance of the quick high-temperature sterilization processes as used in the present sterile canning system, assuming a minimum process for the destruction of heat-resistant spores such as those of clostridium botulinum to be Fo = 4, with an added 100 percent margin of safety (Fo = 8), the comparable process times for equivalent sterilization processes at various temperatures will be as follows:

Relation of Temperature and Time In Equivalent Sterilization Processes

Process Temperature °F	Process Time Minutes	Sterilization Value Fo
214	800.	8
232	80.	8
250	8.	8
268	0.8 (48 seconds)	8
286	0.08 (4.8 seconds)	8
304	0.008 (0.48 seconds)	8

It will be seen from the above relationship of temperatures and time for equivalent processes over a wide range of temperatures that extremely short processes are adequate for sterilization in the higher temperature range. It is quite generally recognized in the food processing industry, that the natural flavor, color, texture, and vitamin constituents of fresh food ingredients are retained to a higher degree through the short-time, high-temperature sterilization process than in the conventional canning process in which the same food components are subjected to prolonged heating in the lower temperature range.

The retention of quality in foods sterilized by the quick high-temperature process, is explained by the fact that the lethal effect of heat in the destruction of bacterial spores increases at a very much higher rate with increasing temperature than the chemical changes which are responsible for the degradation of flavor, color, texture and vitamins initially present in the fresh food materials. In fact, the sterilizing effect or lethality of the heat treatment with increasing temperature, time being constant, increases ten-fold with each increase of 18° F. in process temperature, while the chemical reactions or changes which are responsible for degradation of quality factors involving flavor, color, texture and vitamins, show only a two-fold change for the same increase in process temperature. In other words, the lethal effect of the heat treatment in the destruction of bacterial spores increases ten-fold while chemical reactions involving changes in the food constituents are increased only two-fold (doubled) for each increase of 18° F. in process temperature. The practical significance of this temperature-time relationship is that it makes possible the sterilization of food products in the higher temperature range with minimum change in flavor, color and vitamin constituents.

The advantages of the quick high-temperature sterilization process used in conjunction with the aseptic canning procedure are that it not only makes possible the production of finished canned products of better flavor, color, texture and vitamin content than an equivalent process in the lower temperature range, such as is used in conventional canning methods, but it also provides for continuous high-speed canning operations with more precise automatic controls, with consequent savings in labor, heat-energy and cooling water costs.

Having considered the advantages of quick high-temperature sterilization and aseptic canning methods we now come to the question as to why more progress has not been made in the commercial applications of such methods since their discovery more than thirty years ago. The answer to this question is that aseptic canning methods have, until recently, been confined largely to liquiform foods. The problems of handling solid type foods through the quick-heating, holding, cooling and filling operations had to be solved before the aseptic canning methods as such could be extended to a full range of food products.

It was to meet this need that experimental work on the development of equipment for quick high-temperature processing of particulate type foods was undertaken by the writer and associates in the Heublein, Inc. organization at Menlo Park, California. The immediate objective of the work was to design a complete equipment system for processing and canning particulate foods (solid-liquid mixtures) such as beef stew, chicken a la King, veal scalopini, beef strogonoff and other meat and vegetable mixtures, without attrition or disintegration of the solid food components. The sequence of operations, carried on as a continuous process in the complete equipment system, (5, 6, 7, 8, 9) includes:

(1) pre-cooking or blanching of each of several solid food components for optimum palatability, (2) metering each solid component and liquid continuously in required proportions, (3) heating the mixture quickly to process temperature in the range of 285°-300°F., (4) holding the product mixture at such process temperature for sufficient time to permit heat-penetration into solid components for complete sterilization, (5) cooling the mixture rapidly to 100°-120° F., (6) filling the cooled sterile mixture into presterilized containers, and (7) sealing sterile closures onto the filled containers under aseptic conditions.

The equipment and methods of the new process have been carried through the experimental stages of development and subjected to tests in which many thousands of samples of particulate soups were packed. The several items of equipment embodied in the process constitute a complete equipment system for processing and canning not only particulate products such as meat and vegetable mixtures, creamed vegetables, sand-

wich spreads, dessert puddings and other convenience foods, but the same equipment system may be used equally satisfactorily for canning liquiform foods (10, 11). Last, but not least important, the equipment and methods of the new system are adaptable for sterile packaging foods in all types and sizes of containers, ranging from the smallest baby food size to 55-gallon Sterilpac drums - and without sacrificing the improved quality made possible by the quick high-temperature process.

References

(1) Ball, C. Olin, 1923, "Thermal Process Time for Canned Food." Bulletin of the National Research Council. National Academy of Sciences. Vol. 7, Part 1, No. 37.

(2) Ball, C. Olin, 1928, "Mathematical Solution of Problems on Thermal Processing of Canned Food." University of California Publications on Public Health. Vol. 1, No. 2, pp. 15-245.

(3) Ball, C. Olin, 1938, "Advancement in Sterilization Methods for Canned Foods." Food Research, Vol. 3, Nos. 1 and 2.

(4) Martin, W. M., U. S. Patent 3, 018, 184. Aseptic Canning Process and Apparatus, Jan. 23, 1962.

(5) Martin, W. M., U. S. Patent 3, 041, 185. Aseptic Canning, issued June 26, 1962.

(6) Martin, W. M., U. S. Patent 3, 101, 752. Aseptic Filling Machine, issued Aug. 27, 1963.

(7) Martin, W. M., U. S. Patent 3, 138, 178. Aseptic Canning System, issued June 23, 1964.

(8) Martin, W. M., U. S. Patent 3, 146, 691. Heating Device, issued Sept. 1, 1964.

(9) National Canners Association Laboratory Manual for the Canning Industry, 1956, 2nd edition, Chapter 12, page 37.

(10) Robe, K., 1963, "Martin Sterile Canning. Part I." Food Processing 24, (10): 82-85.

(11) Robe, K., 1964, "Martin Sterile Canning. Part II." Food Processing 25, (1): 74-76.

OUTLOOK FOR UTILIZATION OF SOUTHERN FOOD CROPS

by
J. C. Miller, Head
Department of Horticulture, Louisiana State University
Baton Rouge, Louisiana

Probably no other area of the world offers greater opportunity for the production of food crops for processing than do the Southern States. The climatic conditions present almost a year-round growing season, and, in most instances, the soil is ideally suited, particularly with proper nutrition and irrigation. Another factor in favor of this area is the availability of land and the reasonable closeness to the major centers of population. Finally, in many sections of the West people are occupying some of the better land and are competing for the limited water supply, which is already bringing about a shift to our area.

Until recently the whole philosophy was to produce for the fresh market. However, a big change has taken place in this concept. Consider the case of the orange as an illustration. Twenty-five years ago I recommended that we plant more orange trees in Louisiana. We were discouraged in doing so since many people, including some of our administrators, believed that there would be an oversupply. However, the rapid utilization of frozen orange concentrate, which is being processed by Florida and California, has completely changed the picture, and the demand for this product exceeds the supply.

The same growth applies to our sweet potato industry. Pardon my citing this example, but it is a problem on which we have placed major emphasis and have furnished foundation seed not only to Louisiana growers but to practically all other States now producing this important crop. At this time we are

processing over 50 percent of our crop and are supplying more than half of the total amount of sweet potatoes processed in the United States. Fifteen plants are now canning sweet potatoes alone, and an equal number include sweet potatoes as one of the products they process. In addition, Louisiana has two freezing plants and two flaking plants. Through production, marketing and processing of this crop, more people are employed in Louisiana than in any other crop except cotton. The orange and the sweet potato represent two good cases as to what can be done with a crop if the individuals interested will devote time and energy to developing the product as well as the processing phase.

Some of our other vegetable crops that could be greatly expanded are southern peas (cowpeas). Every Southern State has a production program and, in most cases, a breeding program with southern peas. However, this enterprise is still in its infancy insofar as processing is concerned. A few of the States, for instance, Arkansas, Texas, and Tennessee, are canning and freezing a considerable amount of southern peas, but we have never completely supplied the market with this product.

Irish potatoes. While we are doing a fair job of supplying the market with fresh potatoes, this area is not meeting the demand for potatoes for chipping, flaking, and freezing. Here again, every State that grows Irish potatoes is now growing some of the varieties developed by the Louisiana station, namely, Red LaSoda, LaRouge and LaChipper. We hope to meet some of this demand with the LaChipper.

Onions. At the present time the White Creole is the best variety available for keeping quality, and it has a solids content of around 15 percent or better, which makes it one of the very best varieties for processing as flakes or powder. However, we have left it to Mexico and California to realize its full potential.

Okra. Louisiana, Georgia, Tennessee and Arkansas are growing a considerable acreage of okra for canning and freezing for the various soup companies. It is the second crop in importance for processing in Louisiana. Okra is an excellent food crop and is one of the better products for freezing. We might consider it one of our best summer vegetables. Again, this has come about by the introduction of better varieties.

Broccoli. At the present time broccoli is one of the leading crops to be utilized for the frozen trade, yet, except for Texas, we are growing a very limited amount of broccoli for that purpose. Other areas, such as California, are supplying this crop.

The processing of several other important crops, for instance, tomato, spinach, collards, mustard, turnip greens, snapbeans, Lima beans and beets, could be greatly expanded.

Pepper. For some time Louisiana has been known for its hot pepper condiment industry, and we are doing a fair job for the enterprise by furnishing better seed stocks of the leading varieties of Tabasco, Sport and Cayenne. Workers in Georgia have bred better varieties of pimiento, and that State is one of the leading pimiento areas in this country. Production and utilization of these could be greatly expanded over their present status, since we are importing a considerable quantity of these products.

Cucumber. Very few of us realize the quantity of pickles that are consumed and the importance of this product. Many areas throughout the South are now growing cucumbers for making pickles, particularly North Carolina, Texas, Arkansas and Louisiana. While this crop is not so remunerative, it does give employment to a good many people at a time of the year when farm income is at a low ebb.

Fruit Crops. The peach is one of the South's most universal fruits and leading States, such as the Carolinas and Georgia, could expand in production of this crop, provided quantities of these could be canned or made into other processed forms. The claim that southern peaches do not produce a good canned product is untrue. I believe that Dr. Woodruff would agree with me that many fine products can be made from the peach.

Fig. We have so much confidence in the future of this crop that we have one of only two active breeding projects in the United States. The other, in California, aims at a different objective. Our objectives are early production, cold resistance, a very tight eye to prevent spoilage and processing quality; while California's program is to develop varieties for drying. This past season one of our processors was able to furnish only

a small fraction of a half million dollar market for fig preserves.

Under the heading of small fruits, we have strawberries, blueberries and blackberries, and all of these are being increased in a big way in the Lower South. We might not be able to compete too much with the strawberry area of the northwest, but we do have a season following our fresh market season at which time the berries could be frozen and utilized locally. This is particularly true of Tennessee, and, to some extent, of Louisiana, North Carolina and Florida. North Carolina and other Southern States, such as Georgia, are producing the newer varieties of blueberry which have been developed in recent years, and we hope to utilize the new varieties in building a blueberry industry in the Hammond area of this state in the not too distant future. The Texas blackberry certainly offers a big challenge for quick freezing and for making preserves.

How can the increase in processing be brought about as have the Florida orange and the Louisiana sweetpotato industries? First, we must have a group of energetic people who will take the interest and promote the crop. We must have a group of plant breeders to recognize the opportunity of these industries and breed varieties that are suited for the purpose of supplying the fresh market as well as the processing trade. We must have a group of bankers and others, including agriculture administrators, who believe in developing these crops. It was only a few years ago at a similar meeting that we discussed the possibility of producing sweet potato flakes. Today, it is a reality and we have two plants in Louisiana, two in North Carolina and others being considered for Virginia and Mississippi.

We are in a fast-growing area. Industry is moving south, and we can utilize many of these products in our own area rather than having to ship to distant markets.

This is not a Chamber of Commerce speech. It is a subject in which I am very interested, and I know that any one of these crops could be developed into a thriving enterprise if progressive thought is given to mechanization and processing. Give us men with vision.

RADIATION PRESERVATION OF FOODS

by
A. F. Novak, Professor and Head
Department of Food Science and Technology
Louisiana State University
Baton Rouge, La.

Low-dose ionizing energy appears to offer considerable potential for application in the preservation of foods. This process has been under investigation for a number of years, but it has been only recently that concentrated efforts were made to overcome some of the problems known to prevent commercial application. Radiation should be used for the preservation of the fresh, natural qualities of perishable foods from harvesting through transportation and distribution, or as an adjunct with canning, freezing, dehydration, salting, and other preservative practices in increasing the shelf life of many foods. It can be employed to inhibit insect infestations, control sprout formation in tuberous vegetables, sterilize containers, alter the nature of yeasts, molds and bacteria, or cause their destruction, inactivate enzymes, and obtain certain nutritional changes.

The overall irradiation of foods program was designed to solve specific problems for each class of foods, and many factors must be considered. These include: (1) Experimental evidence that no unacceptable changes in flavor, odor, appearance, texture or nutritive properties develop at the necessary dose level. If such changes occur, methods for their prevention or masking must be developed. (2) The cost of irradiating per unit or package must be reasonable. (3) Safe facilities must be made available for commercial application. (4) Sufficient scientific evidence must be accumulated to prove the safety of the process in order to obtain FDA approval. (5) The public must be educated in the advantages involved, and that the process results in safe foods. (6) How can the process be employed with other forms of preservation now in use? (7) Where in the production and distribution chain would the radiation

process best fit? (8) What type of process would be most desirable; central, mobile, or in plant? (9) What would be the desired optimum extension of storage life, and what dose is required to obtain this extention? (10) What is the possibility of this process expanding or developing new markets?

This is only part of the story. In addition to solving these problems, the mechanisms involved in spoilage prevention must be determined for each food under consideration. Problems to be considered are: (1) Chemical reactions such as oxidation, enzymatic alterations, denaturation, fragmentation, polymerization, and those producing physical changes in solubility and viscosity. (2) The presence of micro-organisms and insects. (3) Damage from rough handling or being packed under ice may lead to rapid contamination, or undesirable tissue damage. (4) Storage conditions after radiation must be proper. (5) Suitable packaging is necessary to prevent foreign odors from being absorbed, mechanical failure in the form of splitting or tearing, coatings which will not alter the product, and the permeability must be considered.

During or after irradiation the food must not develop a characteristic radiation flavor and it must not lose its fresh original flavor.

Microbiological problems must be recognized because many spores resist high radiation doses. In low-dose radiation treatment Clostridium botulinum and Clostridium perfringens spores survive and produce toxins under anaerobic conditions. Therefore, survival of these organisms during radiation and subsequent storage must be investigated thoroughly.

The Department of Food Science and Technology, at the Louisiana State University, has been awarded a number of grants during the past four years to make a comprehensive investigation of preserving gulf shellfish by gamma radiation. General results obtained to date are described in this paper.

Low dose irradiation of shrimp with cobalt 60 results in an extension of their iced storage life of 10 days or longer than nonirradiated shrimp from the same catch. Gamma irradiated ice-stored raw shrimp shell on and shelled, were superior to the nonirradiated product in all chemical and bacteriological tests and organoleptic attributes used to evaluate quality and acceptability. A dose of 0.15 to 0.20 megarad gave maximum protection without any undesirable chemical or physical changes. Some shrimp tested were purchased from commercial boats, and the results suggest that large-scale radiation is feasible, even when the shrimp are held iced for 2-3 days prior to radiation.

Organoleptic trials were also conducted at Ft. Lee, Virginia involving 238 servicemen as panelists. The shrimp (400 lbs.) were purchased from a commercial seafood processing plant in Berwick, Louisiana. They were deheaded, deveined, shelled, packed, frozen and shipped to our laboratories in a refrigerated truck within two days of catching. Two hundred pounds of the shrimp were irradiated at 0.2 Mrad. All 400 pounds were frozen and shipped in boxes containing dry ice by personal auto to insure safe and rapid arrival at Ft. Lee.

A statistical evaluation of the results indicated that "average ratings obtained for the irradiated shrimp at all test meals were sufficiently high for the item to be considered acceptable as a component of standard meals. On the basis of the above, it is apparent that the storage life of fresh shrimp can be extended from 7 to 14 days by the use of pasteurization doses of radiation without adversely affecting the relative consumer preference for this item."

To have a valid comparison when treating raw and cooked shrimp to be stored at 32° F. and 36°to 40°F., samples for all trials were processed from the same batch. It is difficult to compare various treatments with different batches of shrimp, because of variations in fishing areas, weather conditions, purity of wash waters, ice and containers, and the cleanliness on boats. These factors combine to cause considerable initial differences in shrimp for each experiment, and unless all treatments are from the same catch, comparisons are difficult.

From these experiments, results have been verified that both raw and cooked shrimp stored at 38° to 40°F. after radiation (0.15-0.20 Mrad.) do not have the keeping qualities comparable to those radiated and stored in ice. Cooked, radiated shrimp lose some original flavor, but retain their other attributes. Some shrimp were organ-

oleptically acceptable after five weeks even when the chemical results suggested complete spoilage.

Canned shrimp have been radiated, but the flavor and texture are altered unfavorably during commercial processing. Procedures for moisture and flavor retention in canned shrimp are being developed.

"Black spot" was virtually eliminated in most radiated samples. Since melanosis results from the action of phenol oxidases and tyrosinase in shrimp, it can be assumed that these enzymes are inactivated or destroyed at this radiation dose. Effect of radiation on these enzymes is being studied.

RADIATION-RESISTANT MICRO-ORGANISMS

The morphology and metabolism of radiation-resistant bacteria isolated from shrimp were studied to ascertain if radiation (0.1 to 0.2 Mrad) altered their characteristics. Radiation-induced differences were observed in optimum incubation temperature, morphology, chromogenesis, carbohydrate utilization, and action on litmus milk. Radiation lowered the optimum temperature of several organisms 12° to 15°C. Since shellfish are usually preserved under refrigeration, growth of these organisms at lower temperatures could cause a problem, and is being investigated.

Since the production of indole has been employed as an index of spoilage, it was interesting to find that none of the radiation-resistant organisms produced this compound. The negative indole tests correlated with organoleptic acceptance of the radiated shrimp after four weeks storage. This emphasizes the role of radiation in eliminating most of the micro-organisms responsible for rapid decomposition.

The metabolism in radiation-resistant micro-organisms can be altered by low-dose radiation. In processing shrimp, the development of chemical and physical methods which inhibit these changes may be necessary if they are found to increase the spoilage rate. In conjunction with radiation, such processes could increase the storage life.

RADIATION CHANGES IN FLAVOR COMPONENTS

Volatile fatty acids were isolated from samples of radiated (0.15 to 0.20 Mrad) and nonradiated fresh gulf shrimp, and compared by gas-liquid chromatography. Acids found included formic, acetic, propionic, butyric, valeric, caproic, myristic, palmitic, stearic, arachidic, N-behenic, and isobehenic. Results showed that both samples contained the same acid fractions C_1-C_6 and C_{14}-C_{22} and their isomers, and were present in almost exact qualitative and quantitative relationships with the exception of C_{20} and C_{22}. The concentration of C_{20} was lower, and that of C_{22} was higher in the radiated samples.

Carbonyl compounds were present in both the radiated and nonradiated samples, and included acetaldehyde, propionaldehyde, isobutyraldehyde, N-butyraldehyde, 2-methyl-1-pentaldehyde, 2,4-pentadienal, 2,4-pentadiene, 2-hexanal, 2-octanal, citronellal, and acetone. Acetone was present only in the nonirradiated samples. There were no other qualitative differences. Slight quantitative changes were produced by radiation.

Amino compounds identified were trimethylamine, ammonia, methylamine, dimethylamine, ethylamine, propylamine, and butylamine. Changes in the radiated samples were a reduction of trimethylamine and ammonia, and an increase in the methylamine content.

RADIATION INDUCED CHANGES IN THE KINETICS OF SHRIMP ENZYMES INVOLVED IN SPOILAGE

The effects of low-dose gamma irradiation with cobalt 60 on the iced storage life extension of fresh shrimp were investigated. It was found that doses of 0.15 to 0.2 Mrad administered to brown shrimp (Peneaus aztecus) prior to storage in crushed ice, significantly reduced the degree and amount of melanosis, and resulted in a retention of the desirable organoleptic attributes of the product.

Studies conducted on irradiated solutions of phenolase showed that the enzyme was

inactivated. The radiation-induced changes were found to be different from those reported to occur upon denaturation of proteins. Infrared absorption spectra revealed that deamination had occurred. Acid and base binding groups were reduced in number rather than increased, and the optical rotation became more dextrorotatory rather than levorotatory. It was further shown that the copper of the enzyme was not oxidized by a dose of 0.2 Mrad.

The presence of oxygen was shown to enhance inactivation of the enzyme, while the presence of ovalbumin in the phenolase solution protected the activity. This was accepted as evidence that indirect action of the radiation was responsible for the inactivation of phenolase, since the presence of dissolved oxygen or protein would have no effect on direct collisions of the gamma rays and the enzyme molecules.

The liberation of sulfhydryl groups was not detected after irradiation of 0.5 percent ovalbumin solutions. Since it was shown that the presence of inert protein protected, rather than inactivated phenolase, it was concluded that thiol groups, produced by disruption of disulfide bonds in the protein, had no significant role in phenolase inactivation.

Irradiation of the substrate, 3,4-dihydroxyphenylalanine, accelerated the reaction. Therefore the alteration of substrate by irradiation was not found to be responsible for the decrease in melanosis observed in fresh shrimp.

Reports indicated that the phenolase responsible for melanogenesis of shrimp was located in the shell and concentrated primarily at the joints between segments. It was concluded that water and oxygen may diffuse through these joints, and it was their radiolysis products which were responsible for the inactivation of phenolase and subsequent reduction of melanosis.

Irradiation of commercial shrimp in which melanogenesis has begun accelerated the reaction. It was postulated that the quinone-like end products of the reaction sequence acted as competitive inhibitors for the reaction, and also functioned as radiation protectors for the enzyme. Subsequent irradiation would destroy the capacity of the end products to inhibit the reaction and simultaneously preserve the enzyme activity, thus accelerating further melanogenesis.

It was ultimately concluded that low-dose gamma irradiation of fresh shrimp reduced melanosis and resulted in a significant extension of their iced-storage life. However, if shrimp were held beyond the onset of melanogenesis, subsequent low-dose irradiation accelerated blackspot formation, which reduced consumer appeal, and therefore was definitely undesirable.

USE OF LIQUID NITROGEN FOR SHRIMP

In exploring all opportunities and possibilities to insure commercially fresh shrimp for irradiation, studies have been conducted on the use of liquid nitrogen in tanks. These tanks, containing wire baskets could be placed aboard commercial trawlers, and since they could eliminate most or all of the ice requirements, the ships would be in a better position to carry small irradiators, or else maintain a better product until they could be irradiated in certain areas around the coast.

Preliminary tests have shown the shrimp stored in liquid nitrogen to be superior to ice-stored controls from the same catches on the same boat.

RADIATION PASTEURIZATION OF OYSTERS

Many problems have plagued the oyster packers during the past five years. One of the most severe has been from the rejection by State health departments of oysters held in transit for extra days while being shipped from one growing and packing area to another and then being repacked before final shipment to the ultimate distributor and consumer.

Although the excessive bacterial counts might not have posed an actual health hazard, they were above the counts allowed in the standards. Most rejected samples could have been retained as acceptable if some simple method would have been available to reduce the original bacterial counts in the oysters to afford them a few days of extension of quality which would be required for such operations.

Based upon extensive investigations on gamma radiation of fresh gulf oysters, it appears that such treatment of oysters can

provide advantages for the fisherman, processor, distributor and consumer. If such a method of processing were developed to successful commercial application, fresh oysters could be made available to consumers who presently are able to obtain only the canned or frozen product. Market prices of oysters, presently subject to fluctuations due to overabundances or scarcity, would tend to be stabilized.

Experiments on low-dose gamma radiation of oysters have been highly successful. The iced storage life extension of the oysters was sufficient to permit the additional handling time required by the packers to distribute the oysters to inland cities in an acceptable condition (meets bacteriological allowances for shellfish). Various city and State health departments have diverse opinions on what to reject. No laboratory has established any significant meaning for the limitations presently placed on the bacterial populations. Note that with oysters, an unacceptable product (bacteriologically) may become acceptable after irradiation, providing the initial organoleptic rating was good.

DISCUSSION

Question: Dr. Novak, what were you irradiating this material with, what rays?

A. F. Novak: We were using a cobalt 60 irradiator, 10,000 curie, located at the Nuclear Science Center, Louisiana State University. The advantage of using gamma irradiation is that you have a high penetrating value. As you know, gamma rays will penetrate stainless steel several inches thick, so there is no problem whatsoever in penetrating packages of the product. Commercially, we would like to have a belt conveyor on which we would place the produce and have it pass between the sources of radiation. The speed with which it passed through would determine the irradiation dose.

Question: I didn't quite understand that picture where you showed the irradiated against the nonirradiated shrimp. How were they kept in the interim?

A. F. Novak: Iced storage. I pointed out that all of these samples have been in iced storage only. The time we kept the shrimp at lower temperatures was when we were attempting to develop a better procedure for handling the shrimp, from the time they were taken out of the water until they were irradiated.

We have argued for a long time that the problem of distributing so much deteriorated shellfish is due to the fact that the fishermen do not employ proper procedures to preserve the product from the time they catch them, until they sell them to the packing companies, or if the packing companies own their own boats, until they pack the products themselves.

Question: Were those shrimp in contact with the ice or were they in a package?

A. F. Novak: The shrimp were in Mylar packages; although I can tell you from experience, you would have had similar results had those shrimp been in contact with the ice--providing the ice had been clean. The problem is that as the ice is dripping down, the moisture, although being very beneficial, still contains microorganisms, and therefore is recontaminating the shrimp. In order to have uniform samples, we had to place both the control and irradiated products in packages, because we didn't want our irradiated products to become recontaminated after being irradiated.

Question: Is the dosage required for non-formation--anti-formation--much different from the bacterial dose?

A. F. Novak: It all depends upon the organism. We found we prevented black spot formation with approximately 0.15 to 0.3 Mrad. This gives the best results for the prevention of melanosis. The dose for inhibition of microorganisms might be very low, but the spores could cause a problem. A dose of 4,500,000 rad is required to destroy spores of C. botulinum.

There has never been a case of botulism from shellfish in the gulf area. We are making every effort to isolate Type E toxin, and have one professor; Dr. Grodner who has a full-time grant trying to isolate the toxin from shellfish, and from mud and water in growing areas.

Question: The order of time on extended ice storage of the pasteurized product (irradiated, pasteurized product), looked to me about the same as the order of extension that is gotten with chlorotetracycline. I think this was approved as an adjunct.

Would you comment then on the position of these two methods?

A. F. Novak: When I mentioned use with other processes, I could have added the use of washes and dips. Personally, I object to the use of antibiotic dips, because organisms build up resistance; and it is my personal opinion that most antibiotics have better medical applications than they do for food preservation.

Question: You have shown that doses of 150,000 or 300,000 rad that you mentioned are quite beneficial for pasteurizing. What biochemical changes did these pasteurizing doses produce?

A. F. Novak: Practically none.

Question: Such as?

A. F. Novak: All of the information it tabulated. You will find it in the report which is being submitted.

Question: Because many food products demonstrate changes at this dosage.

A. F. Novak: Yes, this is a long story. Let me just give you a few examples. We found some changes in the methylamines. There were some in the dimethylamines and some in the carbonyls and fatty acids. They were slight changes.

Question: You pointed out the difficulty in flavor evaluation. I was just wondering how you could compare the flavor change with the quality change in the frozen shrimp, whether this was primarily a textural change due to the denaturing of the aureomycin as contrasted to the quality flavor changes on storage -- say the refrigerator or even the irradiation?

A. F. Novak: This is a public acceptance test -- preference of the public. They will purchase what they prefer as long as the price is right and the product is available.

Question: I realize that; but how are we to attack the quality problem, if the deterioration of the quality in the frozen shrimp is not due to chemical change, but a textural change?

A. F. Novak: Who said it was?

Question: That was my question.

A. F. Novak: There are some chemical changes. We had not explored this because of the time-consuming element. We are obligated to the USAEC to study the non-frozen product. I am sure there are other changes.

There are many factors which I probably should have pointed out. Indole, for example, is used as an index of decomposition of shrimp. Many oysters taken from the gulf areas cannot meet the bacteriological standards either for coliforms or for total bacterial count. Now, as far as I am concerned, and I am sure others would agree, these oysters do not constitute any health hazards. It just happens that the standards set up by the Shellfish Sanitation Committee are based upon general averages in various oyster-growing areas.

Yet here we have an oyster which couldn't be accepted by the Health Departments in Indianapolis, Chicago or Louisville prior to irradiation. After irradiation of the product, if it was then carried into those cities, the total count would be within the acceptable limits. The coliform count would be within the limits, and the total bacterial count would be satisfactory. Here now you have a completely unique situation. If this situation alone was used as a criterion to determine whether or not radiation was beneficial, as far as oyster preservation is concerned, it would mean the difference between having a nonacceptable product which you would have to discard, and having an acceptable product which you could market.

I'd like to go back just a minute to your question on aureomycin. We have performed considerable research on aureomycin through the years, and have found quite a number of advantages with aureomycin. There are disadvantages when the organisms developed some resistance, but every process you employ appears to have some disadvantages. I would like to recommend the use of more physical methods in foods. I will put it this way. I do not like to see an additive employed unless the additive is definietly required and serves a lasting purpose. Naturally, when you ask a question like that, I am sure you realize that someone must base an answer on many, many factors, and to explain all of these opinions would require an extended discussion.

Question: Is this portable unit considered as a prototype to a commercial unit that may be used on fishing vessels?

A. F. Novak: It is supposed to be -- there are two problems involved. We were hoping they could reduce the weight to 12 tons; the present one is approximately 16 tons. But I would have to answer yes, that it is a prototype, and we are going to make both on shipboard irradiation and land studies with it. It will be large enough to handle small-scale commercial production.

Many problems are involved -- much red tape for getting approval from all of the State and Federal agencies.

HYDROSTATIC COOKERS

by
V. O. Wodicka
Hunt-Wesson Foods
Division of Hunt Foods & Industries, Inc.
Fullerton, Calif.

Dr. Hawkins, ladies and gentlemen, in order to set some sort of perspective for hydrostatic cookers, I am going to have to cover some collateral ways of doing the same sort of thing.

Since the invention of canning by Nicholas Appert something over 150 years ago, there have not been too many major changes in the art he developed. Three that might be singled out are the invention of the tin can, the explanation of what he had accomplished when Pasteur came along with his ideas on microbes, and the courage to achieve the 250° temperatures that Dr. Martin mentioned by pressure cooking.

When you realize that the achievement of this kind of temperature by processing in an enclosed vessel implies the generation of 15 pounds per square inch gauge pressure on vessels of rather considerable area, you can also realize that some 50 years ago when these ideas were first contemplated with relatively primitive metal-working practices, it did take a certain amount of courage to do this sort of thing in the kind of crossroads endeavor that canning was at that time. If we then look at the pressure process that is a necessary approach to the preservation of non-acid foods and look at the ways in which this has conventionally been achieved in vegetable processing, we see that, particularly in the Midwest and the East, this has been done in a batch retort operation (a retrot being the canner's own particular jargon for his pressure vessel), usually in vertical form. This is a sort of a heavy cast kettle with a lid dogged down to hold the pressure. Typically, these are arranged in a circle with a crane in the center. If we trace the flow of the cans as they come off the filler, the cans are deposited in a metal open-work cylindrical basket with a heavy bail. In the early days, a man stood there with a board as the cans were spewed off the end of the line and directed the cans so that they were jumble packed in the crate (so-called bang-board), so that there was a lot of air space around the cans for circulation of steam in the process. More recently, it has been customary and our preference, in order to have nice symmetrical cans without dents and creases all over them, to put layers and separators in between the layers of cans and to stack them all neatly and vertically in the basket. The basket is then conveyed, usually on a monorail system, to the retort circle that I mentioned, where the crane operator puts typically 2 or 3 baskets in each retort. The retort is then closed and steam pressure applied. You allow venting time for the air to be replaced by steam. There is a timed process. Typically, there is water cooling to some extent in the retort to relieve the pressure that would otherwise buckle the cans. Then the retort is opened; the crane carries the baskets around to another point at which another monorail takes the baskets down to another place to finish the cooling. If you stop to analyze this process, you will realize there is a considerable amount of labor going into it to transfer these baskets, to operate the crane, and to close the retort. When the retort is started through the process, there is either a considerable amount of instrumentation that is required to automatically keep track of it for safety, or else you have to rely on a skilled operator who

will usually not be confined to an 8-hour day during the processing season. The strain can be quite severe on his keeping track of this, which is the key to the safety of the whole operation.

Typically, in meat canning and in the Western practice, a similar arrangement is used in which the retort is horizontal rather than vertical; and instead of being deposited by crane, the baskets are picked up by fork lift from the loading point, conveyed onto a track, and pushed through the retort on wheels. Preferably the retort has doors front and back, so that you don't get confused on what has been processed, although a one-door retort is not unknown. Here again there is a considerable amount of labor, even with materials handling equipment in getting the carts, which are typically rectangular or square rather than cylindrical in this case, from the loading point to the retort. The retorts can be considerably larger by being made horizontal, which means that the investment on control equipment is less. In other words, you have fewer retorts for a given volume of pack, but this still gets to be a substantial investment in control equipment and maintenance problem.

The next step in the development of pressure processing was the Anderson-Barngrover cooker, in which the horizontal cylinder I have just described is still used, but in this case the ends are closed. The cans are conveyed in on a track. They are locked into the chamber through a star valve. They are deposited in a spiral track that goes around the internal periphery of the cylinder and are conveyed through this spiral track by a series of radial blades that extend between the cans and rotate, governing, therefore, the speed with which the cans are carried through. Obviously, the cans can be conveyed from the filler to the retort by continuous conveyors, and this required considerably less manpower. There is only one instrument controlling the whole operation. Once set, the processing time and temperature are easily automatically controlled. Therefore, this system has many virtues over the traditional batch retort operation. There are a few difficulties. One of them is that the spacing of the radial blades and of the spiral tracks in the retort is pretty well tied to the can size; and if you happen to be packing several can sizes, this entails quite a changover operation between sizes. The next thing is that this star valve locking the cans into and out of the retort is subject to the typical ills of any mechanical operation and can jam and damage the cans. If you do get a jam and get the cooker stopped, you have a pretty good load of cans in there that will get overprocessed; so you can get into some complications of what seems like a pretty simple and straightforward operation.

The ingenious thought occurred to various people that there would be a much simpler mechanical way of getting cans into and out of the pressure chamber, and that is to carry the cans through essentially a barometric leg of water. This gave rise to the hydrostatic cooker. We have two such units--the Mitchell Hydron--in our David plant. There are other manufacturers. I shall discuss them briefly later to show some of the differences, but I will indicate the Hydron as a typical hydrostatic cooker, and give you some idea of how it functions and what some of its special properties are.

Figure 1 shows an overall view of the hydrostatic unit. There is considerably less floor space occupied by such a unit than by either the Anderson-Barngrover continuous cooker or certainly by a series of batch retorts. On the other hand, it takes considerable head room, which does not necessarily have to be under roof, however. Many of these units, particularly in Europe, are installed outside. This gives you an idea of the general shape and contour.

We will see what it looks like inside (figure 2). The cans are conveyed through the unit by a chain system. The point of loading and unloading is on the left, as you can see. As the chain comes up the mesh opens out, the processed cans drop out, and while the chain is still open, a new load of cans comes in on the one side of the chain. Then it is flexed the other way, and a similar operation is carried through unloading and loading on the other side of the chain. The chain then loaded goes up to the top of the up leg. If desired, there can be a preheating phase where steam is introduced to bring the can temperature up. Then the cans pass down through a water leg. There is, surprisingly enough, an upward water gradient with the cool water increasing in temperature as it goes down. This heat balance is maintained in part by crossflow between the legs with external connections that aren't shown on this diagram. As the can passes

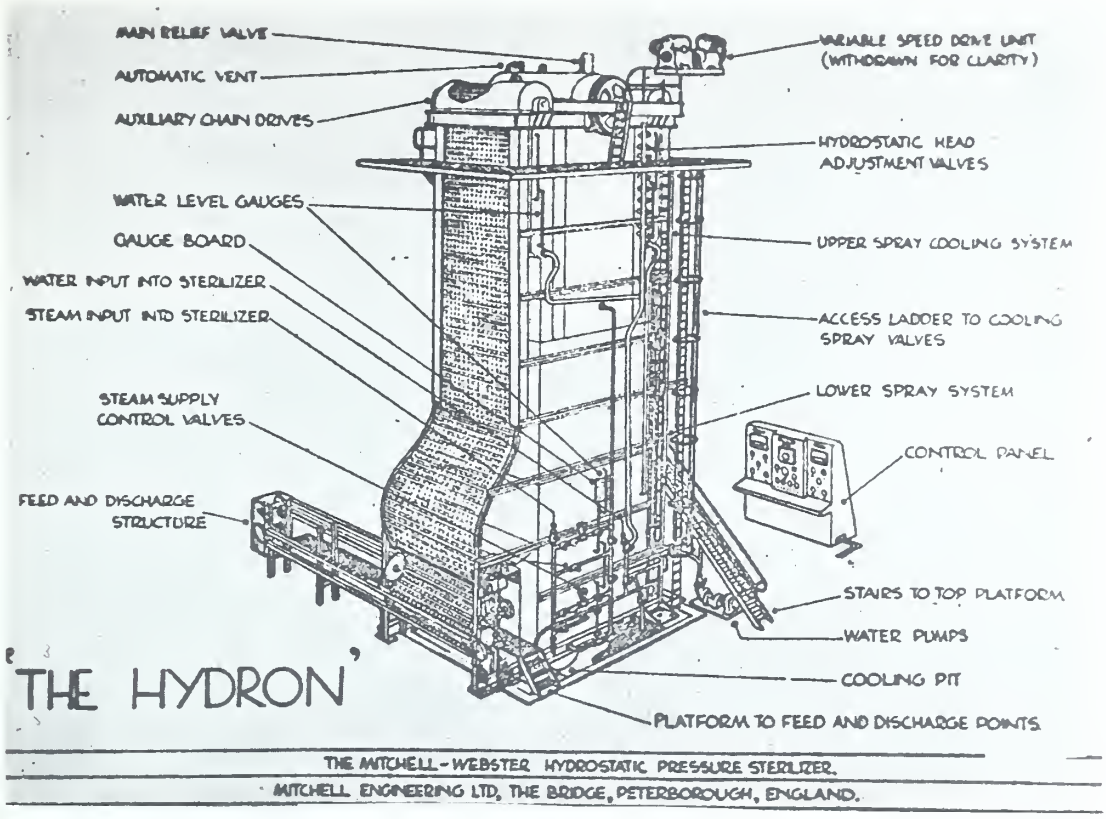

Figure 1.--Overall view of hydrostatic unit.

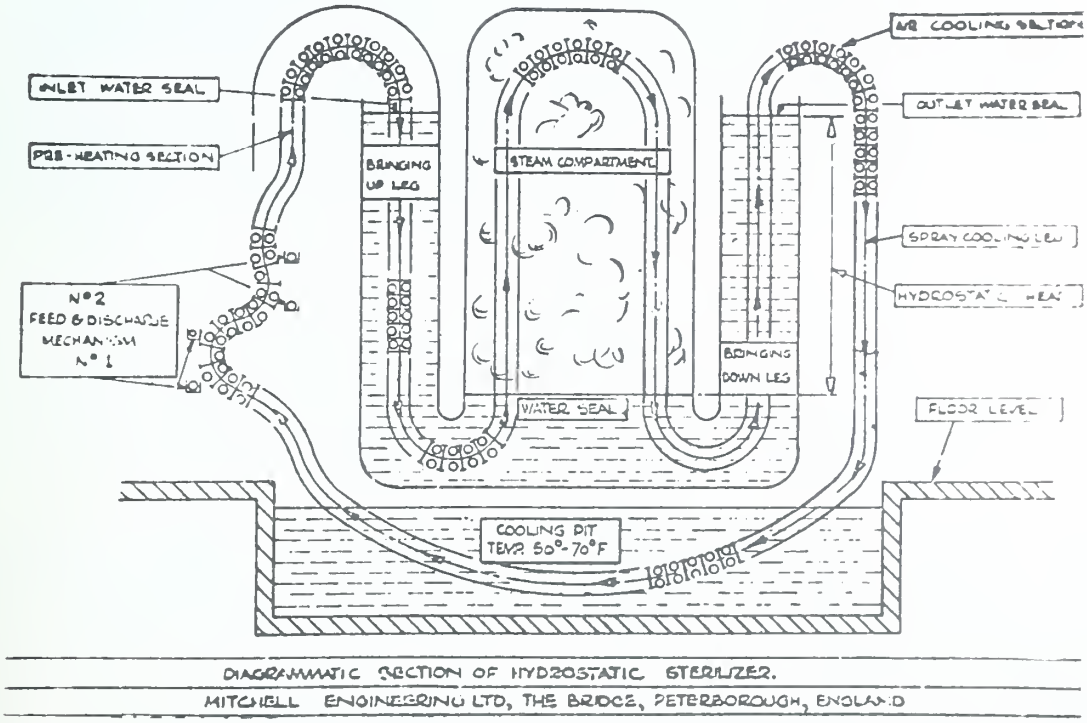

Figure 2.--Inside view of hydrostatic unit.

down the water leg, the pressure obviously builds up and at the same time the temperature is building up, as you get a gradual heating effect. Then the cans pass into the steam chamber. There are several flights of chain going through the steam chamber for the longer processes. Finally, we go out through another water leg which cools the cans down. The high temperature is at the low end and the low temperature at the high end, so you get a gradual cool to the point where the cans are down to atmospheric pressure. Then they go down through a vertical leg with spray cooling. The spray in the upper part is water from the pit. As it gets down to the lower part of this spray leg, fresh water is brought in. That is where makeup water is introduced. Then the cooling is completed by being passed through a pit and back here to the discharge point. The loading of the chain, by the way, is in long rows. The cans go in horizontally and are pushed into a loading rack and then dropped into the chain aperture.

Figure 3 shows a typical temperature profile of a can passing through a unit of this kind. This is the initial temperature of the product being filled in at the container. The temperature obviously goes up as the can goes down through the water leg to this point, at the turnaround down at the bottom of the water leg where they go into the steam chamber. There is still some increase in temperature in the steam chamber. Then it holds level in the steam chamber; then as you go into the cooling leg, it obviously starts to drop. There are a couple of breaks in the curve as you go through various air sections, where you transfer the can from one section to another and finally come out cooled.

The temperature of the process can be fairly simply regulated by changing the height of water in the column and changing some of the controls; and the gauge pressure corresponding to various process temperatures is shown along with the head of water in the intake and outlet legs necessary to counterbalance the pressure in the steam chamber (figure 4).

Figure 5 is a plot showing the throughput as a function of temperature or vice

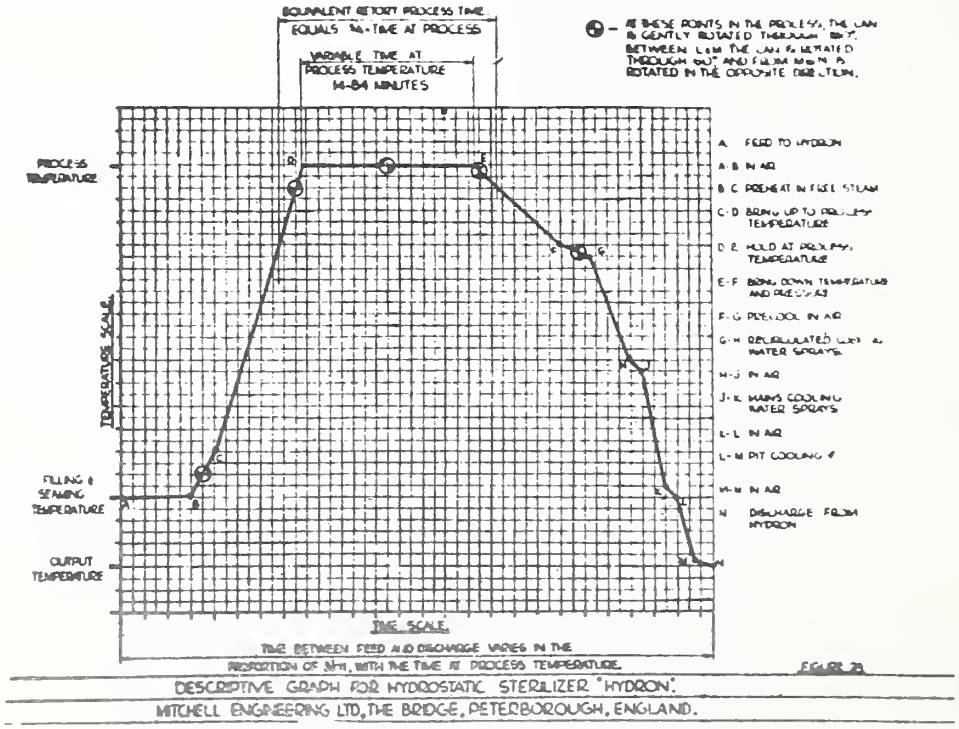
EQUIVALENT RETORT PROCESS TIME
EQUALS 14-TIME AT PROCESS
VARIABLE TIME AT PROCESS TEMPERATURE 14-84 MINUTES
PROCESS TEMPERATURE
FILLING & SEAMING TEMPERATURE
OUTPUT TEMPERATURE
TEMPERATURE SCALE
TIME SCALE
TIME BETWEEN FEED AND DISCHARGE VARIES IN THE PROPORTION OF 3½H, WITH THE TIME AT PROCESS TEMPERATURE.
A FEED TO HYDRON
A-B IN AIR
B-C PREHEAT IN FREE STEAM
C-D BRING UP TO PROCESS TEMPERATURE
D-E HOLD AT PROCESS TEMPERATURE
E-F BRING DOWN TEMPERATURE AND PRESSURE
F-G PRECOOL IN AIR
G-H RECIRCULATED WATER SPRAYS
H-J IN AIR
J-K MAINS COOLING WATER SPRAYS
K-L IN AIR
L-M PIT COOLING
M-N IN AIR
N DISCHARGE FROM HYDRON
DESCRIPTIVE GRAPH FOR HYDROSTATIC STERILIZER "HYDRON".
MITCHELL ENGINEERING LTD, THE BRIDGE, PETERBOROUGH, ENGLAND.

Figure 3.—Temperature profile

Temp. °F.	Press. psig	Head ft
230	6.08	14
240	10.27	26
250	15.15	37
260	20.72	51

Figure 4. --Temperature process

as cans, because of their gentle handling. There is a Carvallo Company that is also a European firm which makes similar equipment.

Mitchell, whose equipment we have, in England, and FMC, in this country, are now making units of this type. Stork has an American agent, and Carvallo also has an

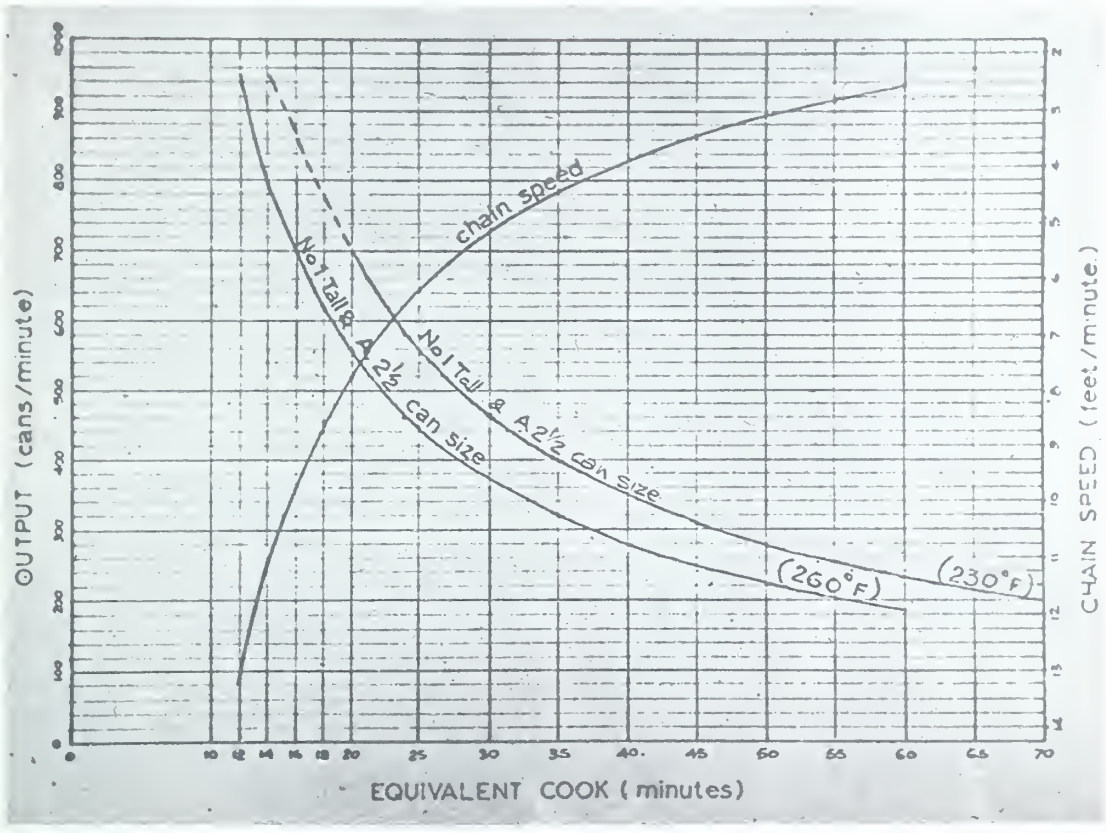

Figure 5.–Plot showing throughput function

versa, with the cooking time in minutes shown on the abscissa, the cans per minute throughput rate as ordinate. Here is a function showing chain speed, and here are a couple of typical relationships for a number 1 tall can or a number 2-1/2 at two different temperatures.

As you can see, the principle of this operation is fairly simple. There is an increasing number of installations both in this country and abroad. As far as I am told, the first company to bring out a commercial device of this sort was Stork in Holland. They have a number of installations in Europe, most particularly in milk processing. You can handle glass in any of these units as well

American representative. Therefore, they are rather freely available in this country. As I say, FMC has at least one installation in, and Stork has three or four in now and about five more on order. So far as I know, I think we have the only two Mitchells. Now, there are some differences in detail in these units. Stork is the only one that gives the option of an agitating cook. In the Anderson-Barngrover continuous cooker that I mentioned, the predecessor development to the hydrostatic cooker, the motion of the cans around the periphery of the cylinder is a rotary one. Therefore, there is agitation of the contents of the can, thereby shortening the process time for many items. Except for the special Stork units

that provide positive agitation, the hydrostatic cookers do not typically provide internal agitation for the cans. So it is a still cook in this respect.

FMC makes a special virtue of the fact that whereas the Mitchell unit that I have shown has only one chain, FMC has two that can operate at different speeds. You can, in the unit that I have shown, operate with two different can sizes at the same time, putting different sizes on different sides of the chain. However, you are tied to the fact that you have only one process time for one chain speed as indicated on that last chart; whereas with two chains, you have the opportunity for running can sizes with different process requirements simultaneously, if this is a problem.

Obviously these units with different features are available also at different prices, so when it comes down to a question of what is your best choice of unit for your particular job, you would have to take all these particular considerations into account in making your choice--just like buying an automobile. I think the principles of this operation are sufficiently simple as to need no elaboration. Perhaps if there are any points that need to be brought out, they can be brought out better by questions than by further systematic presentation.

DISCUSSION

Question: Did you get a different heat penetration rate with the can in horizontal packs rather than vertical; and if so, how do you compensate for it?

V. O. Wodicka: You can't load these things vertically. I think all the units carry the cans horizontally. It gets a little tricky determining your process values because of the fact that it is a mobile system; and unless you have some of these clockwork type recording thermocouples, it gets hard to follow what is happening going through this thing. There are simulators available from each of the manufacturers whereby in laboratory measurements you can arrive at process values. However, it is not quite as straightforward as using the typical thermocouple cans that you use in a still retort. We have checked out the specifications with a recording thermometer in cans, and we find that the units perform as promised.

Question: You do not use Bulletin 26-L as a basis for processing? This is an NCA bulletin.

V. O. Wodicka: In our case, the items for which we are using the equipment are, in the first place, acid. In the second place, they are such that the cooking requirements are in excess of the process requirements. Therefore, we don't have to get too much concerned with this.

Question: You use the raw acid foods, then?

V. O. Wodicka: That is right.

Question: Have you processed asparagus spears? Are the horizontal cans recommended for asparagus spears?

V. O. Wodicka: I am sorry, I don't know.

Question: How long does it take to change the chain in case you want to go to another can size?

V. O. Wodicka: You don't have to change the chain. You just put the other can in. In other words, the chambers on the chain are large enough to hold a wide assortment of can diameters. Of course, the length is not critical, and if you have a smaller diameter than that, it doesn't make a great deal of difference. The can is confined. You don't get much rolling around or damage, and anything up to the chain maximum dimension can be handled by the compartment with no particular difficulty. You noticed that at the entrance point the chain spread out and then the chain came together again, so that the elements on the outside closed that space and the can can't fall out. We have had no particular difficulty with can jamming or anything of the sort in the cooker.

Question: You mentioned this star valve lock system. Are there other advantages and disadvantages of this type of static unit compared to the other spiral?

V. O. Wodicka: Well, as I mentioned, the change of can size on the hydrostatic units takes nothing in particular except to feed in a different can size unless, of course, the process conditions are different. In this case there would take some adjustment. But even so, it is a matter of minutes to make a changeover rather than hours--to pull the

whole inside of the cooker out and replace it. Therefore, the can size flexibility is one important consideration.

Question: Can you tell us a little about the chain itself, what it is made of, what the bearings are, how long a chain lasts, how much trouble it is to repair one, and what happens when one breaks?

V. O. Wodicka: The chain is made out of different materials, as are the bearings, depending on the manufacturer. These are some of the features that I mentioned that the various manufacturers use in argument against one another. In some instances they are aluminum, in some instances stainless, and in some instances a little bit of both. They differ in how they are lubricated. There is much discussion about relative chain life, most particularly the relative importance of water conditioning as a controlling factor determining this. I can't tell you much about chain life because we have only been operating this unit for about 3 years, and we haven't seen any evidence of difficulty at this point. We have made no replacements.

Question: Is there any difference in the way you handle looking for leakers?

V. O. Wodicka: No, not particularly. What do you have in mind, typical seam examinations? You do have this problem where you have a panel or other faulty can through excessive vacuum.

It is possible to get jams on the discharge mechanism. However, this is an unusual sort of thing and controllable.

Question: Has anybody done any work on shorter times without taller temperatures by using liquids other than water? It seems like it would be very possible.

V. O. Wodicka: If you go to shorter times, you would have to raise your temperatures.

Question: Can you go to higher temperatures and shorter times by using nonaqueous medium, or even aqueous mediums with something like salt?

V. O. Wodicka: It seems like I have read something of this, but I don't know of any practicable application of it.

Question: There was one interesting development some years ago by one food manufacturing company, and that is the mixture of vapors. By using higher boiling liquids, they did get an excellent heat transfer. Also, they had a rather ingenious method of testing the thermocouples by contact at different stages where the thermocouple would come in contact with a strip which would carry the current through the shell. However, this was a rather ingenious method and was abondoned because of the effect of the solvent on the compound.

FIFTH SESSION: Panel Discussions

"NEW HORIZONS IN FOOD PROCESSING"

V. H. McFarlane
Southern Utilization Research and Development Division,
Chairman

Ladies and gentlemen, welcome to this fifth session of our meeting. I am pleased to see so many of you here. I hope that you will take advantage of the opportunities this morning to ask questions of the panel members. Also, if there are previous speakers here that you did not have an opportunity to question before, we would be glad to have their topics brought up for additional discussion as time permits.

As Dr. MacDowell has said, we will have a series of five talks this morning before we open the discussions. I am not going to take much time to introduce these gentlemen to you. They are not only well known but they are very highly qualified in their respective fields.

The panel topics are especially interesting. You will note that we are starting out with a discussion of raw material improvements. Then we will get into production. Incidentally, there is a substitution here--Mr. McCaffery for Dr. Wornick. His talk presents a rare opportunity to learn more about

production problems in freeze drying. We do not get too many production people on our programs.

We have a man to discuss flavor modification. Certainly flavor is one of the interesting topics today because we are all interested in getting the flavors back into foods that are lost during different processing steps.

We have a man to discuss quality control which is also a highly important subject because quality control provides the means for getting good quality and healthy foods to the consuming public; and more frequently than not, increased returns to the processor.

We have another gentleman to discuss the consumer wants.

This morning's program "New Horizons in Food Processing," promises to bring you new information. We hope it will stimulate new ideas which you may profitably put into practice.

RAW MATERIAL IMPROVEMENTS

by
J. M. Lutz
Market Quality Research Division
Agricultural Research Service
U. S. Department of Agriculture
Hyattsville, Md.

Fresh fruits and vegetables are living, breathing organisms. They undergo physiological changes during the interval between harvesting and processing. We try to prevent undesirable changes during this period or promote desirable changes during this interval. This morning I will review with you a few of the things we know about behavior of fresh fruits and vegetables as related to processing quality and suggest a few possible future developments.

Most fruits and vegetables start losing quality the moment they are harvested. Usually we can slow these changes by refrigeration. Sugar loss in asparagus is an example. You will notice how rapidly sugar is lost at 70° F. Sugar loss is a little less at 50° F. and considerably less at 32° F. But even at 32° F., we get substantial losses in sugar content.

For most fruits and vegetables the optimum storage temperature is just above the freezing point, which is usually around 30° or 32° F. There are a number of exceptions.

Sweetpotatoes are unhappy at temperatures below 50° or 55° F., and we all know that bananas should not be kept in the refrigerator. Other commodities need more intermediate temperatures. Snap beans are best stored at around 40° or 45° F.

We have differences even in varieties. For most apple varieties we recommend 30° or 32° F. But for McIntosh or Yellow Newton as grown on the Pacific Coast the recommended temperature is 38° F., because at 32° F. they are damaged.

For most commodities that are best held at 30° to 32° F., when we raise the temperature to say 40° F., we merely shorten the storage life. That is not true of all commodities. Peaches, for example, if held for any length of time at 40° F., would not ripen satisfactorily when removed from storage. If you raise the temperature up to 50° or 55° F., they will go ahead and ripen, although slowly.

Before leaving this matter of temperature, I want to point out that it is not enough to merely put the product in storage. The actual temperature of the commodity needs to be lowered within a reasonable time. If you should put bushel baskets of spinach tightly packed in a cold storage room, chances are the temperature would rise rather than fall. It is virtually impossible to cool this fast respiring, tightly packed product by convection.

Refrigerated storage is commonly used to extend the processing season of a number of crops, apples, pears, peaches, snap beans, carrots, to name a few.

Storage of some commodities before processing can even improve the final product. Pears, for example, which develop the

best quality when ripened after picking, are harvested when mature but still hard. If ripened immediately after harvest, they ripen with great lack of uniformity.

Ezell and Diehl more than 30 years ago demonstrated that Bartlett pears sometimes had to be sorted once or twice before canning because of failure of the fruit to ripen uniformly. After storage for 15 days at 30° or 32° F., they all ripened at the same time, so sorting was no longer necessary.

Wiley and Stembridge at the University of Maryland demonstrated the effects of maturity and storage on the starch content of apple slices and the relationship of this starch content to the firmness of apple slices. Apples which produce slices that are too hard for processing at the time of harvest are acceptable after a period of cold storage.

Cold storage before ripening effectively reduces rhizopus rot in freestone peaches. This is often a troublesome problem during ripening of peaches. Pearson, Neubert, and co-workers in the Northwest found peaches ripened immediately after harvest developed an average of 5 percent decay. Comparable peaches ripened after a period of 2 weeks' storage at 31° F. had only about a tenth as much decay.

However, this treatment does not control brown rot which is troublesome in the East and in the South. Dr. Smith of our Beltsville Laboratory has found that hot water, 1-1/2 minutes at about 130° F., is very effective against brown rot and rhizopus rot of peaches. This treatment is being adopted by the industry. We understand there will be several shippers using this method for shipment of fresh peaches, and I would guess that this treatment might have a place in the control of decay during ripening of peaches for processing as well.

Storage does present problems in canning of sweetpotatoes. Pectin and carbohydrate changes that occur during storage, which make a sweetpotato suitable for baking, make it undesirable when you can it whole. So sweetpotatoes have to be canned as soon as possible after harvest.

Julian Miller, sitting in the audience here, tells me he has some varieties that will counteract that effect, at least in part, but we do have that problem, and I imagine some day some imaginative scientist will find out how to arrest these changes during the curing and storage period.

We have been hearing a good deal about supplements to refrigeration to extend the life of fresh fruits and vegetables. A few chemicals are used for a few products as supplements for postharvest decay control. I am sure that safer and more effective fungicides will doubtless be developed in the future, although I hope that we will not be using more than we are now. I don't like using chemicals if we can help it.

Controlled atmosphere, CA as it is known in the trade, is used rather extensively for lengthening the storage season of certain varieties of apples. Interest in CA has increased rather markedly in the last few years.

There are two reasons for this. One is the availability of liquid nitrogen at a reasonable price, and second, the availability of systems for externally generating a controlled atmosphere in a moderately tight, ordinary cold storage room.

Considerable research on this subject is being conducted at the present time by State Experiment Stations, by industry, and by USDA. When there is a beneficial effect of controlled atmosphere, it is usually, but not always, from low oxygen rather than carbon dioxide accumulation.

Each kind of fruit and vegetable has its own CA requirements, the same as it has its own temperature requirements; and with apples, different varieties of apples have their own CA requirements.

From time to time, we get requests for information on the possible value of ozone to preserve product quality. To date, experimental evidence suggests little value from ozone. One part per million is harmful to strawberries and lettuce.

Ozone also has potential hazards to man. So we see little potential value from this treatment, although we are currently studying this problem further at our Beltsville Laboratory under controlled temperatures and known ozone concentrations.

We know there is going to be more and more mechanical harvesting of crops,

particularly for processing. We hope that mechanical harvesting does not damage the products more than hand harvesting. However, with tree fruits which are apt to hit branches as they fall, we can expect more injury than with hand harvesting. These injuries make the fruit more susceptible to decay, so the interval between harvesting and processing will probably have to be shortened, or we may have to use refrigerated temperatures where ambient temperatures now suffice.

Possibly chemical or other decay preventative measures such as hot water or hot air treatments will need to be used. We are continually obtaining new knowledge on the control of diseases during the postharvest period, and I am sure some of this knowledge will be applied to the needs of the processing industry, particularly as related to mechanical harvesting.

Better methods of predetermining processed quality from the raw product should improve the processed products of the future.

The tomato juice colorimeter is being used more and more each year to predict from samples of the raw tomatoes how red the catsup, soup, or other processed products will be. Because color affects the prices paid for processing tomatoes, the grower has an incentive to deliver a better product to the canner.

Other procedures use light transmittance techniques to predetermine product quality and will probably be used to sort commodities for internal defects. Hollow heart, which is often very troublesome in processing potatoes, can be detected without even cutting the potato. Sonics are another technique which appears to offer promise in determining quality, particularly texture of agricultural products.

Before closing, I want to comment briefly on irradiation. We heard good results it had with shrimp and oysters yesterday. Unfortunately, with fresh fruits and vegetables we don't have that hope.

We ran fairly large-scale tests in 1963 simulating as far as possible commercial conditions at our Fresno Laboratory. We had the Canadian mobile irradiator available to us. Out of 22 fruits and vegetables tested, only 3, strawberries, mushrooms and 2 of 3 varieties of fresh figs, were not damaged by the treatment. For most of the others, we had darkening and softening at dosages which were needed to control decay.

We are continually developing new information on methods of handling storage and decay control of fresh fruits and vegetables. As we obtain this new knowledge, we will be applying it to the needs of the processing industry.

THE FUTURE OF FREEZE-DRIED CONVENIENCE FOODS

by
T. J. McCaffery
United Fruit Food Corp.
Edinburg, Tex.

In any discussion of convenience foods it is well to establish what we mean by "convenience."

To primeval man convenience in food meant, perhaps, coming across a freshly-killed animal that he did not have to stalk and club to death.

To us today convenience in food takes many forms, the dry soup mix, the flip-top can, the frozen dinner, the instant coffee. Each provides a certain amount or quality of built-in "maid service" and as such is not absolutely convenient.

As one engaged in the freeze-drying of foods, I am not here to suggest that freeze-dried foods provide absolute convenience because they do not. For that matter, no food is totally convenient, be it in packaging, cost of shipment, storage life, ease of preparation, or overall quality.

Frozen foods, for example, are usually of excellent quality but they have to be kept frozen if they are to keep from spoiling and are therefore useless to a camper who has to carry his food on his back.

Canned milk is good but it doesn't compare with the fresh milk and the fact that

instant coffee or frozen orange juice do not produce the quality of their freshly brewed or squeezed counterpart has not prevented them from becoming multi-million dollar items in the National diet. Their convenient ease-of-preparation has far outweighed the inferior taste.

We have a new generation born to convenience that has a palate for these products. My own children love a glass of orange juice made from the frozen concentrate and will, only with great persuasion accept a freshly squeezed glass. I suppose it's an indication of my age but I still prefer fresh orange juice.

There are indeed many factors that make any processed food acceptable and final taste is only one factor.

Why am I making these observations? Because some people compare a freeze-dried food with its fresh counterpart and find it wanting. A freeze-dried food is, after all, a dry product and there is no more logic in comparing it with the fresh food than there is in attempting to equate a canned pea with a frozen one or in downgrading a prune because it is unlike the plum it came from.

Of all dehydrated foods, those obtained by freeze-drying are the best. In the dry state they are generally lighter than those dried by other methods; they rehydrate almost instantly and retain their original nutrients, shape, and color to a very marked degree.

In some instances, there are freeze-dried foods on the market which are, in fact, superior to the usual quality of those processed by other means or prepared from the generally available fresh ingredients. This occurs only because the freeze-drying processor begins with an exceptionally good product and processes it under conditions that the average chef or housewife does not have at his disposal.

So far, we have compared freeze-dried foods with those processed by other means, but what of those that can only be successfully preserved, by freeze-drying, for an indefinite period at room temperature and still be of a quality comparable to the fresh? Freeze-dried banana slices are a good example, peas are another.

Those of us who are engaged in freeze-drying are certainly enthusiastic about it, but not thereby blinded to reality. Freeze-drying will not make obsolete the convenience of other food preservation methods but will, and at the present time is, creating its own share of the convenience foods market. This ever-increasing share will be obtained by those who maintain an unrelenting standard of quality.

Our continually improving living standards have made yesterday's luxuries today's necessities with the result that the average person enjoys greater comforts than a king of the middle ages.

Armies still travel on their stomachs, but hard-tack no longer suffices. Restaurants survive by serving good food at the reasonable prices made possible by the convenience added to the foods they purchase. Today's housewife likes to provide her family with a variety in meals that she cannot achieve in the time available to her unless more and more "maid service" is added to the foods she buys.

It has been found that freeze-dried foods perform best as components of dry mixes. Because of this, even greater amounts of freeze-dried ingredients are used industrially where they add extra value and convenience to what otherwise might be a rather uninteresting or incomplete product.

"Egg solids," the vastly improved powdered eggs of wartime notoriety have become highly successful instant omelets when combined with freeze-dried ham, mushrooms, onions, or green peppers.

An excellent dry sauce becomes a superb "Shrimp Imperial" when freeze-dried shrimp are included in the package.

A chicken noodle soup mix achieves eminence when actual chunks of freeze-dried chicken are part of the total mix.

What of the housewife who comes home from work just before her husband and wants to have a meat loaf ready and on the table in the time it takes him to shower? Nothing simpler than to open a can with all of the necessary ingredients in it, or, a sure-fire Chicken a la King that is prepared in

the time it takes to get everything else ready?

The armed forces, which have been large purchasers of single-item freeze-dried foods, are now beginning to use mixes such as chicken stew, beef hash, and others.

All of these are realities today, so, what of the future? Freeze-dried foods have made room for themselves in the National diet but we have yet to fully develop their potential and opportunities.

In my hand I am holding some blocks that are very light and taste delicious. You have all eaten this many times but have probably never put it in your mouth with your fingers. A friend of mine took some pieces of this material home and offered them to his wife saying, "Would you like some ice cream?" to which she replied in surprise, "What, in my hand?"

This is freeze-dried ice cream with the ice removed. "So what" you say, "what is it good for?"

Well, for one, you could shape it in a ball, place it on a cone and give it to your three-year-old with the assurance that his clothes, face, and hands would not be dripping when he finished eating it. Better yet, how about enrobing one of these blocks with chocolate and making a delicious candy or making it in the shape of flakes so that you could pack it with cereal and spoil your kids by giving them ice cream for breakfast?

This is an example of the challenging possibilities that the peculiar advantages of freeze-drying can add to an everyday food.

Just as today doctors write prescriptions that could not have been filled ten years ago, I venture to say that within ten years there will be common, everyday foods of outstanding convenience only because of the added value that can be built into them by freeze-drying.

FLAVOR MODIFICATION

by
E. T. Theimer
International Flavors and Fragrances, Inc.
New York, New York

Mr. Chairman, ladies and gentlemen:

When your committee chairman, Dr. Bruno Wojcik, invited me to be a member of this panel, I told him that although my company was vitally interested in all aspects of flavor, I myself was not a specialist in this area. He nevertheless was kind enough to let the invitation stand, and I shall do my best to present several aspects of this subject which seems to be of particular importance not only from an industrial standpoint, but also from the much broader point of view of the general welfare of mankind.

The time factor alone precludes treating all aspects of flavor modification, even briefly, but more important, it seems to me, is not so much a discussion of present practices as a hopeful glimpse into the future, with perhaps some historical background to establish the basis for the optimism.

Thus the present practices of flavor enhancement by replacing flavors lost in food processing certainly are valuable, but are probably only a transitory phase, just as the upgrading of meat and dairy products cannot be a final solution.

As we heard previously, food shortages may be eliminated by developing entirely new food sources, but these will require new sources of flavors to make them palatable. It is with the prognosis for the availability of such flavors that I propose to deal, and for this discussion we shall need some background.

Flavor sensation is composed of the elements of aroma or fragrance, taste, and "mouth feel" which includes the effect of consistency and texture. Since we must learn to walk before we run, a brief consideration of prior studies on fragrances

and results achieved may be appropriate, for in this field the problems, while intricate, are still less complex than the corresponding ones involving the study of flavors.

In the first place, odor is but one component of flavor. It is caused by a reaction of volatile molecules upon the olfactive nerve endings in the nose by a mechanism as yet unexplained. Odor is confined to molecules below molecular weight about 300, or with not more than 20 carbon atoms, probably because of the volatility factor. As far as we know, the composite odor or aroma of even a complex mixture is the additive effect of the odors of its components, and no cases have been substantiated of synergistic, neutralization, or other nonlinear effects.

Natural fragrances, such as flower oils, are complex mixtures, but at least their analysis can be undertaken with large amounts of starting material. Ten kg. of jasmine absolute or otto of rose may be expensive but at least these amounts are available for purchase.

It is for these reasons that natural fragrances have in certain cases been successfully analyzed, leading to fairly accurate duplication by synthesis and blending.

If one wonders at the relatively slow progress in the analysis and duplication of natural flavors, one can find at least a partial explanation in considering the added complications.

1. Flavor has the added elements of taste and "mouth feel" mentioned above.

2. Flavor is often a nonlinear effect.

3. Flavor components are often unstable, and change rapidly even at ambient conditions.

4. Man, and other animals, are extremely sensitive to flavors, fantastically small amounts giving very pronounced effects, and minute changes in composition leading to dramatic differences.

5. The available amounts of flavor for analysis resulting from extraction of tons of starting material is often no more than a few grams, or even less.

Of all these factors, the most challenging but at the same time the least understood is the nonlinearity. It is the basis of much of the so-called culinary art, which has been much admired but little understood. The experienced chef, using only his palate to guide him, with the aid of very common additives such as salt, sugar, spices, essential oils, etc., could create tantalizing, delectable tidbits while the same materials in the hands of one less experienced could lead only to the commonplace, barely acceptable drab foods much too prevalent even today. Such additives were known simply as seasonings or flavor enhancers.

The Japanese had long used natural additives, such as soysauce, seaweed extractives and dried fish to enhance the flavor of prepared foods. Belatedly scientific minds began to wonder why these materials were so effective, and the active ingredients were isolated and identified. This led to the introduction, first, of monosodium glutamate (MSG) and more recently, of the nucleotides, 5'-inosinate and 5'-gyanylate with which you are all familiar. Dignified by the name of flavor potentiators, these materials have created something of a sensation and no little debate as to the mechanism of the phenomenon now known as flavor potentiation. All theories are based, unfortunately, on an almost complete ignorance of the mechanism of sensory perception. Whether a potentiator acts on the sensory organs to change their sensitivity or has a synergistic effect on other components, or imparts a specific flavor note of its own must await further investigation by the physiologist and psychologist.

Significantly, most of the research so far reported has been in the area of potentiating the flavor of meats, fish, soups and certain vegetables. Little is known about possible potentiators for fruits and berries although maltol has shown some effect in some areas. Recently, workers at the International Minerals and Chemicals Research Laboratories have called attention to the strange effect on the taste buds caused by eating the so-called miracle fruit from West Africa, known locally as "agbayun", a native shrub (Synsepalum dulcificum). After eating the fruit, sour foods or beverages taste sweet for the next hour or two. It greatly enhances the flavor of citrus fruit

and they say it makes the delightful flavor of fresh strawberries "so wonderful that it defies description". Curiously, when mixed with sour foods, it has no effect but must be eaten first and allowed to coat the mouth. They have not yet identified the active principle but suspect it could be a glycoprotein. We had a sample of this fruit in our laboratories some years ago and can vouch for its strange effect. Even 95 percent alcohol seemed "cool" after eating the fruit.

In this discussion I have mentioned only the first order of complexity, the direct potentiating action. MSG, which has no flavor in distilled water at 0.01% concentration, can "potentiate" at much lower concentrations. This is true also for the nucleotides. But mixture of MSG and a nucleotide each in subthreshold amounts can be effective, presumably by potentiating each other, and various combination of nucleotides are much more effective than the sum of the components.

Having mentioned some of the obstacles that lie in our path let us go back to the beginning and see how far we have come.

The synthetic flavor industry, in its first stage, from its inception until several decades ago, concerned itself mainly with providing flavors for sweets, desserts, soft drinks, cakes, puddings, and so forth. In short, they were for more or less luxury products not in themselves the essential staples of nutrition. Extract of vanilla and later vanillin, its main ingredient, made by chemical synthesis provide perhaps the classical example. Man then improved upon nature (so most experts say) by synthesizing the next higher homologue, ethyl vanillin, stronger and slightly different in flavor. Essential oils were and are a major source of synthetic flavors used for the same purpose. We are all familiar with lemon and orange oils, peppermint oil and synthetic menthol, and Cassia oil or cinnamic aldehyde to name several.

The above examples represent materials used on a large scale either because of ready availability as natural products, or because of relative simplicity and ease of manufacture in the case of the synthetics. Citral, benzaldehyde, vanillin, cinnamic aldehyde, each is a major flavor ingredient, of lemon oil, bitter almond oil, vanilla, and Cassia oil respectively, and can be obtained more economically either from other natural sources or synthetically.

These early successes soon led to attempts by flavorists to broaden their base of operations, with varying success. Methyl anthranilate provided an excellent base for grape flavor, but strawberry, raspberry, peach, apricot, and many other fruits presented a different problem entirely. In these, the flavor could not be reproduced by available synthetics, although certain vaguely similar effects were produced, for example, certain homologous esters of phenyl glycidic acid give a tolerable strawberry effect, as does gamma undecalactone for peach, and gamma nonalactone is quite like coconut. However, these materials are poor substitutes at best and are not in general acceptable to the sophisticated palate. In addition, these materials, being purely artificial (in contrast with synthetic) present both legal and medical problems in their use.

At the same time, efforts to analyze the flavor of fruits such as I have just listed failed for many years because of insufficiently advanced technology.

In spite of the difficulties previously discussed, significant progress has recently been made in flavor duplication due principally to the spectacular analytical instruments now available. These are no doubt well known to most of you, but for the sake of completeness I will enumerate them. Their function is first separation, then identification of isolated components. The separation is achieved by gas chromatography supplemented by thin layer or column chromatography for less volatile compounds.

These components can be identified partly by elution time under controlled conditions from polar and nonpolar columns in the case of knowns.

Confirmation of structure, or identification of unknowns is achieved spectrographically with infrared, ultraviolet, mass, and nuclear magnetic resonance spectrometers, the first three requiring less than one microgram of sample under ideal conditions, but the last, which can give the most information, requiring at least 1000 times as much even with the highest resolution instrument and using noise averaging techniques. By these methods we have, in our laboratories,

identified over 130 ingredients in the strawberry. Many of these are commonly known and commonly occurring substances found in many fruits. Others have little or no odor or taste. Still others seem to have very interesting odors and tastes and may occur in appreciable amounts. In the first flush of discovery, it is the natural tendency to make use of only those materials which seem to have character and interesting taste or odor. Also, first attention is often given to those components which occur in the largest amounts. We often read that the major constituents of a food have been identified. Several investigators have demonstrated that mixed aqueous solutions of substances can be readily tasted even though each is present at well below its threshold concentration. Since threshold values may be below the sensitivity of our best analytical instruments, this additive or synergistic effect, it may be both, cannot be overlooked if we are to achieve perfection in our pursuit of excellence.

In the light of the unfolding theories concerning flavor potentiators, many of the "uninteresting" substances which have been identified are being taken off the shelf and re-examined. This fascinating subject is unfortunately beyond the scope of this summary, and I have, I am afraid, touched too briefly on it to be of use to the few uninitiated in this audience, while belaboring the obvious for most of you.

Having said that we are now beginning to achieve some success in making quite acceptable fruit flavors, I must now return to my original thesis that this is not the main goal of our industry, nor does it help materially towards amelioration of the developing food shortages so ably discussed by some of the previous speakers. It is all very well to make a flavored gelatin dessert which is recognizable as strawberry other than by its red color, but I suspect that while this may have real commercial value for the marketing of that particular brand of dessert, its overall effect towards nourishing mankind is not revolutionary. We are still in the luxury rather than necessity area. But we are beginning to enter a broader field.

A constant flow of publications is coming from many government, educational and industrial laboratories listing components identified in various foods products. Almost every food has been or is being investigated, including fruits, vegetables, meat, butter, cheese, coffee, etc. In spite of all of this intensive work, no single flavor, as found in nature, has yet been fully and satisfactorily duplicated although vast improvements have been made. Success here is very important, even critical, because of human behaviour patterns. It is said that a drowning man will grasp at a straw. But will a starving man eat straw? Even if it has been carefully compounded, to contain the proper nutritional elements, with protein, carbohydrate, fat and vitamin content carefully balanced, and it tastes like straw, experience shows he would rather starve than eat it, unless he happens to like straw. And that is not exactly a joke.

For when we talk about undernourished peoples, we speak of many different groups, with different backgrounds of experience. Each wants food, but also wants what it has been used to eating, and will reject the unfamiliar. Here at home we eat potatoes, as well as rice, and often prefer them to rice, if indeed we have a preference. We know both, and have learned to eat them. Yet in Indonesia, for example, potatoes are rejected and rice, the familiar, the known, is eaten exclusively. Similarly, peoples who have a lifetime of experience with fish diet will refuse the finest steak. This is no different from our findings that adults do not like chocolate if they never had it as children, or that national preferences in soft drinks are based similarly on familiarity. Even cola, that ubiquitous product, is accepted in many areas more by default than by preference, and the Austrians would still rather drink raspberry juice, Himbeersaft, which finds no market at all in our country.

What then is the role of the flavor industry in all this? It is simply to recognize these national preferences and to make use of them. We can expect that a new source of food, principally protein, whether from soy, peanut, cottonseed, from petroleum by synthesis or bacterial action, from fish flour, or from any other source, can be supplied as a bland, sterile, odorless, tasteless product. All that is needed is a rigorous process which destroys all the viable elements and leaves only the nutritional ones. In the past the difficulty with food processing has been that it attempted to produce a flavorful tasty product, and this was not possible because the flavor elements are among the most delicate and sensitive.

The next requisite, proper texture or consistency can be re-incorporated by various techniques, as we have heard. For example, soy meal can be made to feel and crunch like potato chips, like dessert cookies, or even like hamburger patties.

This leaves only the sine qua non, flavor. And this problem will be, in fact, is being solved. New flavors--whether they are called synthetic depends upon the precise definition of the word--are already available which will make a bland protein material taste like bread, like butter, like potato, or like meat. More specifically the meat flavor can be beef, pork, lamb, or pot roast with pan gravy. Shortly we may be able to say "Name it and you can have it." Surely that time will come before the protein deficit has been overcome by synthesis.

The methods by which these flavors have been produced are varied. They include biochemical, synthetic, and enzymatic processes. Some have been published, others are still too new. In much of this work, the analytical instruments have played a part, for they have provided some knowledge into the composition of natural flavors and have thus helped clear the way for duplication. It is true that in many cases the individual components are very simple compounds, but that does not mean that the problem is simple. For the amounts that are present are so minute, and the composition of the mixture so critical, that gross methods of duplication fail utterly, and final success can be achieved only by flavorists, who, having to a high degree the quality of flavor perception present to some extent in all of us, can use the results of scientific analysis to blend proper mixtures.

It would be unfair, however, to oversimplify the matter by stopping here. We are all familiar with change in flavor with ripening of fruit, cooking of vegetables or potatoes, roasting of meat, and so on. Flavors are delicate, sensitive, and evanescent. Heat above all can change, even destroy. We can put the finest most faithfully reproduced flavor into the raw food, and it may be gone or completely altered at meal time. Again, new techniques are coming to the rescue. One is encapsulation of the flavor material. Thus sealed in, the flavor is protected until such time as release is desired. That release can be achieved by heat, pressure rupture, or solubilization. For example, getting back for a moment to the luxury field, chewing gum flavor, which loses strength and quality during shelf storage of the finished gum, retains its quality and strength when encapsulated, so that less than half the amount of flavor is required when thus protected. The same principle is applicable in most areas of flavor work.

In conclusion, I should like to predict that the flavor industry will continue to make important contributions to the desirability and therefore to the acceptability of all new food products developed from whatever source, and that, thanks to intensified research efforts and new techniques, the rate of the contributions will keep pace with the rest of progress in the field.

QUALITY CONTROL

by
A. Kramer
Department of Horticulture
University of Maryland
College Park, Md.

Since in the next 10 minutes I am to cover all of quality control, the only way that I can do this is simply to touch on the highlights with the hope that those of you who are interested in going to special areas will bring them up later in the discussion.

I would like to start out by saying that the quality control operation begins and ends with consumer or customer specifications; as obvious as this may sound, it is frequently overlooked. Ask yourself when you do your research whether you are really looking at it from that standpoint.

The plant breeders among us, for instance, how often do they throw away some useful material or maintain it unnecessarily because they themselves tasted it and decided it was of no value or vice versa? Similarly, when working with a particular new process, say irradiation, we may become so involved

in our own particular operation that we may decide that the product is extremely satisfactory, better than anything that is on the market, without consulting the potential customer for the new process or product. Actually, it is not the business of the investigator to make that decision; it is the customer's, the ultimate consumer's decision to make. This independent evaluation of customer preference is where a control system should begin. It should end with the customer specifications.

Before any such system can be put into effect, there must be test procedures that are objective, reliable, and accurate, that can be utilized to measure these specifications. Once these tests are available, there needs to be a sampling procedure where the samples of the material are to be tested. This is where statistics come in. A statistical method of sampling will provide us with information at a fraction of the cost that a non-statistical procedure will provide.

Then the samples must be recorded and reported, and here again a statistically based procedure for recording and reporting is far more efficient than one not relying on statistical methods.

Finally, on the basis of these reports, action should be taken when needed and only when needed, so that the consumer or the customer specifications can be met.

Now, to review very briefly these points one by one. What test procedures do we need, and what is available? Although we may often ignore the importance of the appearance of a product, this parameter is perhaps the most important. Generally speaking, there is instrumentation available to test just about any kind of an appearance quality attribute, such as color, finish, size, shape, or visual defects.

Once the appearance factors of quality are overcome, that is, the consumer has made his first purchase, maybe the last, if other parameters are not satisfied, he next looks to what we generally call textural characteristics, such as tenderness, firmness, fibrousness, succulence, mealiness, and others. Here also the instrumentation is available so that the evaluations can be made objectively. I might point to one relatively recent development in this area. Textural measurements are generally those in which force is applied to a product, and the more force that is required, the harder or the more fibrous, the grainier, and so forth, the product is. If instrumentation is utilized in which force is charted, we find that attention should be paid in many instances not only to the peak forces required, but also to the nature of the curve that is obtained.

For example, in studying the effect of calcium salts on firmness and wholeness of canned sweetpotatoes, by the use of a recording shear-press the peak of force obtained is approximately the same for the sweetpotato which had been firmed up on the surface with calcium salts and the one that hadn't. However, when we examine the curve, the potato that had been firmed up will invariably consist of a very sharp rise followed by a gradual descent from the initial sharp peak. The curve for the sweetpotato that had not been firmed up with calcium salts will rise to about the same height, but the slope of the ascending curve will be gradual, and the angle will be less steep though ultimately reaching about the same peak height. The slope of the descending curve for the untreated potato, on the other hand, is invariably precipitous. In this instance, therefore, the shape of the curve gives us the information we are looking for rather than the peak value obtained.

Once we have overcome the problems of appearance and texture, we encounter the problems of flavor. I am not going to repeat what Dr. Theimer has already covered, but I would like to comment on one specific flavor measurement problem on which we are actively working now. This is the utilization of gas chromatography and other instruments providing a wealth of discreet data in attempting to develop an objective means of measuring flavor quality. In addition to the number of instruments that Dr. Theimer had mentioned, I would like to suggest one more, and that is the computer.

It seems to me that a great deal of work has been done with gas chromatographic equipment with little meaningful results in terms of flavor preference. A gas chromatographic analysis is made, a multiple number of peaks, maybe 20, maybe 30, maybe 100 or more are developed on a chart, and then elaborate procedures are undertaken to identify each peak. Then it is usually found that the height of a particular peak bears no relation to its importance in

determining the flavor characteristics of the particular product. That is occasionally, maybe frequently, about as far as the investigation proceeds. Perhaps some substances are identified which were not previously known to be present, but a characterization or evaluation of the flavor of the product is not achieved.

What I am suggesting is that before going ahead with prolonged and expensive procedures for identifying every one of these 20, 30, or 100 peaks, that first a statistical procedure be employed to determine which peak or combination of peaks has a significant effect on flavor response. This procedure is called stepwise multiple regression and can be handled very handily on a computer, but cannot be done with a desk calculator if there are anything like 50 or 100 equations to solve.

By the use of this procedure, then, you can determine exactly which peaks have any significance in relation to the flavor perception of that product by referring each of these peaks in turn to taste panel data on the same samples.

We have done this kind of work with green beans and found that of something like 36 peaks that we isolated, 13 had a statistically significant relationship to flavor perception of the beans as indicated by taste panels. We were able then at this point to discard the others. We didn't need to go ahead and attempt to identify the substances represented by the discarded peaks. We had statistical certainty then that the other peaks had little or no relation to flavor.

Another point relative to flavor quality, and Dr. Theimer had mentioned it, too, is what is flavor really? Is it entirely disassociated from these other factors of quality such as texture and appearance that I have mentioned previously?

From these studies we reluctantly must state that it is not. It is impossible, if we are going to have humans as the ultimate criteria of flavor quality, to disassociate odor and taste responses as determined by a patch in the nose and taste buds on the tongue from other responses. Now, going back then to the same bean example, 13 of these peaks had some significant relationship to flavor response. Our multiple correlation coefficient between these peaks and taste panel scores for flavor preference was 0.76. This means, then, that something slightly better than half ($0.76^2 = 0.58$ or 58 percent) of the flavor response was explained on the basis of these 13 peaks.

When we added a test for texture and a test for size to the multiple correlation in addition to these 13 peaks, our multiple correlation coefficient with taste panel flavor response (not total overall quality) rose to 0.95, thus explaining about 90 percent ($0.95^2 = 0.90$ or 90 percent) of the flavor responses by the panel. This is simply repeating what Dr. Theimer had said, that we cannot, if we are going to use the human as the criterion of flavor response, limit flavor strictly to the taste and odor perceptors in the tongue and the nose.

The next item is the sampling. I would like to refer to the first speaker on the panel, Dr. Lutz. I don't know whether he did this as a Freudian slip or not, but if you recall he had indicated something about the testing or evaluation of raw material, and then he added the words "for processing." I think this is our general thinking, and this is the general status of the industry.

We have gone a long way in developing methods for testing, sampling, and whole system of quality control for processing. We have neglected almost entirely the materials that are purchased in the raw state. Yet there is just as great a need for a quality control system in the production of crops as there is for processed products. I am simply pointing this out without elaboration because of the lack of time.

In-plant quality control is definitely on the increase. The usual point at which a quality system is introduced in the plant is in weight control and the use of control charts.

I would like to point out at this time that there is rapidly increasing interest in using a relatively new procedure called EVOP (evolutionary operations) for in-plant control, where the philosophy is complementary to the philosophy behind the statistical quality control chart.

Finally, I would like to repeat my suggestion that in the growing of the product, not only in the marketing and processing of the product, there is need for exactly the

same kind of quality control systems as are now limited to in-plant use.

Here there is a tremendous amount of work to be done. After all, the production of an agricultural crop from an industrial engineering standpoint is not so different from the processing of the crop after it is in the manufacturing plant. The raw ingredients are different and the product that comes out is different, otherwise the system is the same.

In a similar manner a quality control system designed for the preparation of processed products for consumption may be employed. In this instance the raw ingredients may be processed or fresh, and the control system would regulate the quality of the raw materials and their preparation as meals for the ultimate consumer.

WHAT CONSUMERS WANT

by
H. G. Hamilton
Florida Agricultural Experiment Station
Gainesville, Florida

Consumers vary in their wants. Any casual observer realizes this. However, the reason that consumers vary in their wants is not so readily understood.

In general, income, race, religion, education, climate, occupation, and the degree consumers are exposed to promotions are believed to be reasons for variation in economic wants. Because the time allotted for this discussion is so short, we shall confine our remarks primarily to the effect of income on economic wants.

In countries of people with low income the products that are in greatest demand are those products that yield the most calories for an hour of labor. For any particular product the grade of the product is not important. People with low income will pay almost as much for grade 3 oranges or potatoes as they will for grade 1 oranges or potatoes.

People of an affluent society as contrasted to a low-income society are more concerned with quality than calories. As incomes shift from low to high, demand shifts from low quality product to high quality product, and from low grades to high grades. (The terms "high quality" and "low quality" as used here have reference to economic quality and not to wholesomeness or nutritive value). A good example of product shifts in demand is the shift that has taken place for pork and beef over the past 30 to 40 years. Pork is considered a lower quality product than beef. Using uniform dollars, from 1925 to 1941 when beef prices averaged 70 cents per pound, per capita consumption averaged 52 pounds. But from 1947 to 1956, a period in which real per capita incomes were much higher than the 1925 - 1941 period, when the price averaged 70 cents per pound per capita, consumption was 64 pounds. This was an increase of 23 percent. In the case of pork, from 1932 to 1952 when the price was 60 cents per pound, per capita consumption was 58 pounds. But from 1953 to 1956, when per capita income was much higher and the price of pork was 60 cents, per capita consumption was 53 pounds, or a decrease of 12 percent. In 1964 all cuts of beef (in terms of 1947-1949 dollars) averaged about 70 cents per pound, and per capita consumption was about 100 pounds. At the same price, consumption in 1964 was almost double what it was in the low income period of 1925-1941.

In 1949 per capita disposable incomes (in terms of 1964 consumer dollars) was about $1,772. In 1964 per capita disposable income was $2,248. This was an increase of 27 percent, but consumption of beef increased about 63 percent. A good example of grade shifts of a product is that of round steak and hamburger. In 1949 the price of round steak was 75 cents per pound and hamburger was 51 cents per pound. Steak was about 47 percent higher than hamburger. But in 1964, round steak was 93 cents and hamburger 52 cents per pound, or steak was 79 percent higher than hamburger. Merchants in a low-income area tend to stock products of low economic quality, and merchants in high-income areas tend to stock products of high quality. Often, however, as in the case of beef carcasses, you have to take low-quality product along with high-quality

product. When this is necessary, balance pricing is practiced.

Balance pricing is simply putting a price on the various cuts of beef that will move all cuts uniformly. In stores where people with low income shop, the price margin between low quality and high-quality cuts is quite small, but in stores having shoppers with high income, the margin between high and low cuts is quite large--often twice as great in high-income stores as low-income stores.

Dependable Quality

If any of you purchased groceries 40 years ago, you know how much you depend on the clerk to guide or advise you in your purchases. Under today's shopping conditions the consumer never comes in contact with an employee of the store until she gets to the check-out girl, and at this time she has already made her purchases. The only guide consumers have today in making their purchases is appearance of the product, the brand, the price, and advertisements. In the case of fresh products, the decision is almost entirely on appearance and price. In the case of processed or packaged products, the decision is almost entirely on brand and price. Brands are very important to consumers. A study of consumer purchasing practices in Colonial stores was made in 1962. The study reveals that 80 percent of the customers purchase the same brands of foods today that they purchased yesterday. Different brands were purchased in the other 20 percent of the cases because of special displays, advertisements, price reductions, or on recommendations of a friend.

Demand for Services

Consumers in an affluent society want many high-quality services. They must have convenient parking, air-conditioned and clean stores, and courteous treatment. But more than this, they want the work load in the kitchen reduced. The housewife of the first two decades of this century purchased her poultry live, she did the picking and dressing in the home. But no housewife today will dress a chicken. On the average, Colonial stores stocked 5,854 items per store. Among all of these items not a live fowl was found. Should you take away the built-in maid service of chickens prepared for the pan and replace them with live birds, the sales of poultry would be reduced almost to zero. Housewives' demands for ready-mixed cakes, rolls, waffles, salads, and TV dinners are all evidence of the great demand for more services; ready for the oven or the table is what is wanted and is what consumers are willing to pay for. Twenty years ago the average housewife spent about 3-1/2 hours per day preparing meals--today she spends about an hour. If the housewife performed the services that are performed in the channels of trade, she would receive about 35 cents per hour for her labor. Today about 16 percent of all meals are served out of the home. In a short time this may reach 25 or 30 percent. This trend of eating out is another evidence that people want more and more service. Brands and built-in maid service are important to the housewife for food served in the home, but when the housewife takes the family out for a meal, she has no opportunity to shop by brands. She passes the responsibility of good food on to the institution buyer. She eats at those restaurants that give her good food, and brands or built-in maid service never enter her mind.

Food shoppers for institutions, unlike the housewife, pay but little attention to brands. These buyers are skilled both as to price and quality. Institution buyers are concerned with quality to be sure, but continuous and dependable supplies are perhaps of greater importance to them.

The Nature of Demand

Demand is a very complex subject. Most lay people confuse "preference" with demand. Preference has no price tag attached to it. "Demand" always has a price tag. Most any one prefers a Lincoln car to a Ford car, but the demand is much greater for Ford cars than Lincolns. Most consumers would be hard pressed to determine whether the demand for oranges is greater this year than it was last year. They are also at a complete loss in understanding that the price of some commodities are more sensitive to supply changes than other commodities. An understanding of the sensitiveness of price to supply changes is one of the most important problems in the entire marketing process. The changes in price resulting from changes in supply is of great importance to the food handler. For some commodities, prices change very little when supply increases or decreases. Most food products

have an inelastic demand; that is, a small change in supply affects prices greatly. In general, at the farm level a change in the supply of oranges of 5 percent will change the price from 10 to 15 percent. At the retail level a change in supply of 5 percent will change the price from 4 to 6 percent. Most nonfood items (not all) have an elastic demand, that is, a change of 5 percent in supply affects the price less than 5 percent. People have a way of buying an extra car or TV set with only small changes in price, but they never eat a second dinner because the price is decreased.

Because of the differences in demand elasticities at the farm level and in the channels of trade, we have a conflict of interest between farmers, the producers of food, and middlemen - the distributors of food. A wise and just grower in Florida who wants to increase the income from citrus, prays for a freeze that will destroy 25 percent of everybody's fruit. But it would be a dumb processor that would pray for a freeze which would destroy 25 percent of the crop. The grower's income is increased by a decrease in the crop, the processor's income is decreased by a reduction in the crop. The nature of demand is the reason for conflict of interest between producers and marketing firms. Marketing people who become producers act like producers, and producers who engage in marketing act like marketing people. It is not a case that one is evil and the other good, or that one is wise and the other dumb. It is simply that their incomes are affected differently because of the nature of the demand.

What about the elasticity of demand for service? The demand for services is elastic. A consumer will buy more and more services when these services can be purchased at a lower price than she can perform them herself. You cannot induce affluent people to increase their aggregate food intake. But you can induce them to use more services in the aggregate. In the channels of trade a chicken can be dressed in about 2 minutes - in the home it takes 30 minutes. Because technology can take place faster in the channels of trade than in the home, we can expect to continue to perform more services. In general, the more services performed the wider the spread between what consumers pay and what farmers get.

The reason that eating out is becoming so popular is that institutions are performing the services of preparing and serving meals at a lower cost than the housewife can. Particularly this is true if the housewife works outside the home. Most food institutions buy from purveyors, and purveyors prices are lower than retail food prices. There is probably less waste in institutions than in homes. Furthermore, restaurants are quite adept at increasing services. This is done by using different kinds of furniture, china, and silverware. Services are increased still further when music and other forms of entertainment are furnished with the meal.

In summary, demand is never static--it shifts from product to product and from grade to grade. The trend in demand is a shifting from the low-priced product to the high-priced product, and from the low- or medium-grade product to the high-grade product. The trend is for more and more services. The most cherished want of the consumer is a brand that tells her at a glance all the qualities of the product, especially the good qualities of it. Because of differences in cost, the future homes are going to be hard pressed to compete with institutions in feeding the family.

DISCUSSION

V. H. McFarlane: I hope the members of the panel are prepared to answer the questions which members of the audience bring to their attention. This session is now open for questions. Please address your questions directly to the member or members of the panel. We are ready for questions. Who will ask question number 1?

Question: This is to Dr. Kramer. I'd like to ask about the gas chromatography, the high peaks. You had an Elberta peach. How do you go about identifying that particular product? Is it ester or something else, or what is it?

A. Kramer: I believe Dr. Theimer went into that more than I did as to the identification of it as such. What I tried to point out was that the size of the peak isn't necessarily at all related with its importance in the flavor of that particular product.

You may have a very high peak on a gas chromatogram and it has absolutely no value

as far as the flavor perception of that product is concerned. Before you go to the very difficult and arduous task of attempting to identify all of these peaks that you get, I suggest that you go through a statistical procedure which will select for you only those that have some significance in relation to the flavor. From here on I think I'd better turn to Dr. Theimer.

E. Theimer: If I understand your question, suppose we decide that we want to know what a particular component is. The question is, how do we go about establishing this, is that correct?

Questioner: That is right.

E. Theimer: Well, the first thing we do is to put the entire mixture through a fairly good GLC unit, which will separate out the particular component, together with a small amount of garbage on either side so that, instead of having the component at a 2 percent concentration, we have enriched it to maybe 60 or 70 percent.

This can be done doubly by trapping twice to get the concentration up somewhat higher. You will in no case get it purer by trapping it out on any one particular column, because there will always be other things which elute so close to it that you can reach a certain maximum and that is about all you can do.

The next step is to make a further separation by putting the enriched matter through another column of a different character. If you made your first separation on a nonpolar column--some sort of substrate which does not differentiate too much between functional groups, but on the other hand does separate according to boiling point or vapor pressure--you have probably, if this happens to be an ester for example, achieved a mixture containing no other esters. It may, however, be mixed with hydrocarbons, ketones, and other compounds of different functionality.

The next step is to put it through a polar column, such as polypropylene glycol, in which the separation is based more on functionality of the components. You should obtain a product which will be about 95 or 96 percent pure.

This does not mean simply because this particular material, which you now have separated, has a good odor, that you have a valuable component, because, the nose being so sensitive, the odor still may be due entirely to a tenth of a percent of something else that came along with the main component.

If you really want to know what you have chemically, you can take the material, assuming you have at least a microgram, and do a lot of things with it. If it is a known material, you can identify it readily by the following technique.

Note the exact elution time on polar and nonpolar columns, and classify it according to a known series of tables for esters or acids or ketones or what have you. It is very unlikely that there will be any known compound with the same elution characteristics or retention times on both columns which will not be the same material.

Furthermore, you can confirm this identification by various spectra techniques, including infrared and ultraviolet examination and mass spectrometric determination on less than a microgram of material. You can get the material back from the first two techniques, but not from the mass spectrometric technique.

If you are still in doubt and you have a milligram more, you can do an NMR. Often that will give you the exact structure.

Question: There seems to be an interesting difference of opinion between Dr. Theimer and Dr. Kramer on whether or not certain heights or cell components of a flavor as contrasted with aroma, as to whether certain components of a flavor can be eliminated by some test, whether it is judged statistically or some other way.

I believe Dr. Theimer said there was no possibility of eliminating, of easily eliminating the effects of pure components, because they are able to contribute below their threshold values, and furthermore, there are numerous cases of synergism.

I don't see what opportunities this leaves for any treatment whatsoever, whether used statistically or in any other means of ignoring any of the components or ignoring very many of them.

A. Kramer: I don't know that there was any conflict there. I thought that Dr. Theimer

was prepared to accept my suggestion. In any event, perhaps I ought to go a little further into the particular statistical procedure involved, and this is a stepwise multiple regression analysis where each component is correlated with the panel-flavor evaluation individually as a partial regression with the flavor response of the taste panel. We are assuming in this case that the taste panels are really measuring flavor as they are supposed to measure it. By this procedure, every one of the components is looked at individually for its independent contribution to flavor, and in every possible combination with every other peak that is there. We then end up with a multiple regression equation, indicating just what is the effect of each of these components and all of them together on the flavor.

From a statistical point at least, I don't see how the procedure can miss in selecting the significant components and assigning an appropriate weight to each. A high-speed computer will do a fairly involved problem in a manner of minutes, which would be really absolutely impossible to do any other way.

Question: You mean you need a high-speed taste panel too then?

A. Kramer: No, the taste panel actually tastes the samples, the samples which the gas chromatogram analyzes. In neither case is the analysis nor the values that are obtained very time consuming. Really, the time consuming part is attempting to get these relationships.

You can develop a team, working on a particular product, that can develop information in a matter of say a few months of mandays. Then, by the use of a computer, in a matter of minutes you can get an analysis.

If you do not have a computer, it would take a matter of many, many years of mandays to get this analysis done.

E. Theimer: I would like to comment on this because I confess, I, myself, also puzzled as to how you can get enough valid information. It is true, of course, that the materials which you work with first in considering making a flavor are those which have odor, but it has been quite definitely established that other materials, as I mentioned before, which don't seem to have any flavor or odor characteristics still affect the preference. If you leave them out, the composition is not as good as if you had put them in. I did not understand how Dr. Kramer managed to separate all the components of the mixture in the first place in amounts sufficient to evaluate separately. This has always been a big problem with us. We don't know how to get them out pure and in quantity. Secondly, the high degree of subjectivity of the taste panel was also something that threw us. We might do a hundred evaluations and find finally that A is better than B and B is better than C and C is better than A. We didn't know what to do with that evaluation.

There is a great value in the use of a computer if you have the hard facts to put into it. I must say that I don't myself know yet how we can do this efficiently in the case of a complicated mixture.

A. Kramer: All I can say to that is to repeat that the statistical procedure is at least available. We don't have the time or the opportunity to get into it at this time. The name of the statistical procedure is Stepwise Multiple Regression. And this then, those of you who are familiar with things like interactions will recognize the fact that what we are talking about is an interaction effect, where several of these products are involved.

We don't need to isolate a material and to test it separately. We simply pick off the data from the mass, we will call it mass if you wish. Spectrogram, chromatogram, profile, overall-flavor would be more correct, and assume for the time at least that we are getting reproducible results with the equipment, so that each peak does come in the same place on the chart. For example, if it is there at all, and at the same height, it is there in the same concentration.

The taste panel should also be sufficiently accurate so it does give us similar responses to similar samples.

Question: I'd like to direct my question to Professor Hamilton. Recently, at National Dairy, we have been told that the consuming housewife has been told that the present cost of food is 18-1/2 cents of the consumer's dollar, and that this is the lowest in the history of the United States and also one of the lowest in the world.

This reduction has been accomplished along with supplying convenience foods.

Now, it is to be expected that convenience foods will increase in popularity.

Do you see that the food manufacturer will be able to obtain more than 18-1/2 percent of the consumer's dollar by supplying even more convenience foods?

H. G. Hamilton: Is your question that the 19 percent of the consumer's food dollar goes for food? Or is it that the manufacturer or producer gets 19 percent?

Questioner: We are told that by the grocery manufacturers' association, quoting Secretary Freeman.

H. G. Hamilton: That the manufacturer gets only 19 percent?

Questioner: Supposedly, based upon surveys conducted by the United States Department of Agriculture Home Economics.

V. H. McFarlane: You are saying that the consumer pays 18-1/2 to 19 cents of every dollar, and assuming that the manufacturer gets all of this?

H. G. Hamilton: No, no. No, this is the percent of the housewife's income that is spent for food.

The manufacturer, the transportation company, and the distributor, get about 62 percent of the consumer's dollar spent for food. The farmer gets about 38 percent of the consumer's dollar.

Questioner: Presumably if instead of the 19 percent of the consumer's dollar, she was willing to spend 25 percent, it would be more for the manufacturer and distributor?

H. G. Hamilton: Well, of course she isn't going to spend any more than she has to. I think the manufacturer and distributor are going to give her better bargains in days to come, and she will be only spending 12 or 15 percent of her income for food. In addition to a lower percent of her income going for food she will receive more services.

I don't think you have reached the saturation point by any stretch of the imagination for additional services. I think we are confusing the expenditures for a given service with the expenditures for all services. Processors are likely to receive less income in the future for performing a single service than they do today but in the future they may perform more services and increase their total income. Serving food in restaurants is increasing the services rendered to consumers. It is now estimated that between 20 percent and 25 percent of the meals are served outside the home.

Question: I have a question for Dr. Kramer on this process. Would it be possible where we are dealing with small canners that maybe have only one man, this man maybe has his master's degree but never had a statistics course in his life--can we train this man to use the process without too much effort? I'd like to hear your comment.

A. Kramer: I would say that by definition a statistical quality control procedure must be a simple and easily applied one, otherwise it is no longer a statistical quality control procedure, it is a research and development procedure.

The EVOP procedure that I had referred to can be handled in a relatively simple manner. It just so happens that I have a paper in Food Technology (Sept. 1965-(1377) 71)) rather recently describing it, and I think in very simple terms, so that EVOP can be applied certainly by someone with a master's degree. In fact, I think it can be applied by, I'd say, the average plant superintendent who may not even have a bachelor's degree.

The statistics of it are easy. The application generally is one of looking for continuously, and in an evolutionary manner, find the best possible process under regular manufacturing conditions--that is the philosophy behind it--as compared to the control chart approach which involves maintaining a particular process that has previously been found to be the proper one. That is the difference in philosophy. The statistics for both EVOP and control charts are not difficult.

Question: I have a question for Dr. Lutz concerning the controlled atmospheric storage of products. I am wondering if you could go into a little more detail on that, possibly discuss some of the results obtained, in particular, if any work has been done on the storage of sweetpotatoes?

J. M. Lutz: Well, as you probably know, most McIntosh apples are stored very extensively in the northeast under controlled

atmosphere storage. Here you have a variety that cannot be stored successfully at 31° and 32° F. You have to store it at 38° F. If you are storing at 38° F., you are shortening your storage life in half, approximately. Am I answering your question?

Questioner: I was thinking more specifically of storing and not so much temperature and humidity control as you mentioned, as storing under other materials such as nitrogen and gases. Do you have any results of that nature?

J. M. Lutz: What you are doing is reducing the oxygen, letting the CO_2 build up, and you are slowing down the life processes with controlled atmosphere.

So in effect you are getting a slowing down of living processes, by controlling the atmosphere, the same as you would have had if you had stored it at a low temperature.

You have other benefits too. Jonathan apples are usually stored at 32° F., they will take 32° F. But you have problems with Jonathan spot. With low oxygen and about three to five percent CO_2, you control Jonathan spot.

Delicious apples store pretty well, but a few people want to store them just a little longer, and so by using low oxygen and slowing down the rate of respiration, you can extend their storage life.

All apples don't go into CA storage. All McIntosh don't go into CA storage. McIntosh can be stored until perhaps January in air at around 38° F., but if you want to hold McIntosh until this time of year (March) or later, you need to go into CA storage.

V. H. McFarlane: Many of us are interested in the storage of sweetpotatoes. We'd particularly like to know if there is any work on the storage of sweetpotatoes.

J. M. Lutz: I don't know of any. Lee Kushman at our Raleigh station has done some work. Sweetpotatoes are not very tolerant of CO_2 accumulation. About nine or ten percent is about all they can stand. They are not too tolerant to low oxygen, but I don't know that anybody has ever done any work on it. Maybe somebody in this audience knows something about the CA of sweetpotatoes.

Question: I'd like to ask a question along this line. Is anyone using chemicals along with this storage to slow down respiration? I know some that can be done, they are being tried.

J. M. Lutz: Of course, there are, as I mentioned, some chemicals that are used to control decay. You do have some waxes that give you a modified atmosphere within the fruit itself. But that is not used extensively. Sprout inhibitors are used commercially on potatoes and onions. Kinins have been used experimentally as senescence inhibitors. Here again, maybe someone in the audience knows something that I am not aware of.

Question: The mixed dehydrated foods have become more common now. You particularly mentioned chili. I understand that there is a substantial difference in the stable moisture content for retention of quality of the several ingredients that go into chili.

Is there anything done to inhibit moisture exchange between the several components?

T. J. McCaffery: I would say that ideally you would freeze dry all the components together. For example, in a meat loaf, you could prepare all the ingredients and freeze dry the total combination.

For certain other products such as chicken a la king, there are ideal moisture levels for the different ingredients that go into the mix such as the peas, the chicken, the mushrooms, and so forth. Each one has a value that is considered the best for the particular mix that it is going into.

In the case of the chili con carne that I mentioned, this is a new item that has only recently gone beyond what is called the production test for the Defense Supply Agency. In this case, you use freeze-dried meat, and conventionally dried beans. The moisture in the beans runs between six and eight percent. The meat is dried to below two percent.

I don't know just how much work was done by the Quartermaster Laboratory for the optimum moisture levels required for each of these ingredients. I do assume that the right levels were chosen for the particular storage time that they were interested in.

Question: I have two comments or two questions, one for Dr. Hamilton and one for Dr. Kramer.

First to Dr. Hamilton, at first blush it may be a little disconcerting to realize that 19 percent of the disposal income that the housewife has goes to food. Then you said there is a possibility that this may go down to 12 percent.

I think a previous questioner was asking what would the net effect, as far as income, be on the food processor. Since you pointed out that the housewife will pay for services which would cost her more to perform herself, I would imagine that her services would bring her a greater income, therefore her disposable income would increase and the total amount of dollars going into the food processing industry would increase proportionately. Is this correct?

H. G. Hamilton: No. I am not sure that it is. The housewife, of course, is not going to perform any services that will cost her more to perform than she can buy.

Since technological developments can take place much better in the channels of trade and in a manufacturing plant than they can in a home, you will reduce this cost and she will have more for nonfood items. She will have recreation and many other things to use her income on.

I have said to my classes that if we double the per capita income from what it is now, which would put it around $4,500, then because the cost of food would be so small as compared to our income that it would take only a slightly higher percent of our National income to give everybody free food than it now takes to give everybody free education.

We are spending about four or five percent, maybe six percent of our income for education. If we doubled our per capita income, the cost of our food would run down to around six or seven percent of our future incomes.

This is the situation that we are in. This is the reason why we kick out the farmers. You may have seen recently that we need only a million farmers. We used to have several million farmers. The farmer is going to get a smaller percent of the consumer's dollar, and the processor is going to get a smaller percent of the consumer's dollar, because food is going to take a smaller percent of the consumer's income.

This has been brought about through technological advancement.

Question: If I may, I have a question for Dr. Kramer. It seems to me that in this problem of quality control, the real problem is as Dr. Theimer pointed out, obtaining valid objective measurements of flavor or aroma or taste or texture.

But the dilemma is to reconcile these objective measurements with an objective "subjective" evaluation. Dr. Theimer pointed out that in the hands of the expert flavorist who has the knowledge and the talent which the average consumer doesn't have he can synthesize or make a quality product.

I think experience bears out that this may be an expensive way of doing it unless we can put into practice the system mentioned by Dr. Kramer, because many new products put together by the expert food technologists and flavorists that never passes the market test or gets to a market test, so I think it is worth some consideration if Dr. Kramer could point out a little of the protocol by which the samples statistically representative of the important peaks--I realize these aren't isolated ingredients had in each peak, but this is a food probably representing peaks 7, 8, and 9, and another food representing 8, 10, and 11.

And by making interaction analysis, you get a flavor judgment of the subjective panel which you make objective by your measurements.

Could you discuss this protocol a bit?

A. Kramer: It is primarily a matter of time. I might say this, that the suggestion that I made previously may be strange and peculiar for the chemist because he just doesn't think that way. He starts with a known ingredient and then adds another ingredient to it, and sees how these two in combination affect the flavor response.

Then he may add a third ingredient and sees how each of these three individually react to the flavor response. And then combinations of these three, and pretty soon, they'd be in astronomical trouble.

What I had suggested statistically was exactly the same thing except that you start backwards--you have samples of an item which has all these flavor ingredients, in different combinations and at different levels in each sample. The same set of samples are submitted to the instruments and to taste panels. The computer then does the statistical analysis for you.

Well, to go back then to the actual procedure that we would follow. We would be looking at a food product. This is a complete food product. It is not something that something has been added to. We will say some beans. We prepare a series of samples of beans. They may be different varieties of beans, and for that reason they may be different. We may process these beans differently. We may hold them longer or a shorter time from the time they were harvested until the time they were processed, as Dr. Lutz pointed out. That is a very important time where all sorts of changes can occur in flavor as well as in other qualities. We will prepare perhaps several hundred samples of this kind which we assume will pretty well cover the range for the particular variable of quality we are concerned with, in this case, flavor quality.

Now, we will run each of these samples on gas chromatographic equipment and will end up with a number of peaks. We take replicate samples and in some instances we can take the same sample. In fact, if we have canned samples, the head space gas analysis is usually adequate, and is a very easy way of doing it.

Of course, you still have to control your temperature and other variables to get reproducible responses. Then, we will take replicate samples or even the same samples if we can and submit them to a taste panel. And here again we are assuming that a taste panel is representative of the consumer at large. We do need to take certain pains with the taste panel to assure the fact that we don't have individuals there that have, let's say, tastes that are peculiar and strange and different, although statistically we can handle that too. Then, we do with the computer exactly the same thing really that the chemist does by isolating these components. But we haven't isolated them, we just take a reading.

So, for example, in sample number 1, we have a peak number 1 occurring at a certain height, and we will take the height of it and relate it to the flavor evaluation by the panel on sample number 1.

Then we will take the next sample and look for that same component appearing in the same location on the chart and get its height (or the area under the curve), and relate it to the panel evaluation of that sample, and so on for the hundred or 200 or so samples that we have. We will run a correlation coefficient between the values on this particular peak No. 1 and the panel results. Now, we will do this for every one of the peaks we have numbered but not necessarily identified. Some peaks may be entirely absent in some samples, so that those samples will be recorded as having a 0.0 peak height. We will not be necessarily concerned with high peaks only. It may be that something that adheres somewhere as a spur on another peak may be the thing we are looking for rather than the big peak itself.

After we have made these correlation coefficients for each one of these 30 or 50 or a hundred peaks with the taste panel, then we start looking at them in combinations of two.

And then the machine tells us whether the combination 2 has improved the relationship statistically significantly or not. If not, it will be dropped. If yes, it will be retained.

And all the possible combinations of two are looked at. And then the whole process is repeated with combinations of three and so on. And then in this way, if a particular component has not added significantly by itself or in combination with any other component to the total evaluation of the flavor, then it is dropped, and only then is it dropped.

Actually by looking at the regression coefficients, we can get an idea of the relative importance of each of the components that are selected. There is a great deal more information than this that can be gotten out of an analysis like that. Incidentally, programming this procedure for the 1704 was done at the University of California.

Question: This is directed to Dr. Kramer. It seems to me if you are going to analyze

in this manner that the effects that you are measuring here are the additive effects and not necessarily those brought about by synergistic effects.

I'd like for you to comment on that.

A. Kramer: I really don't know how I can separate the two. If there is a synergistic effect, I don't see why it should not appear as a significant interaction or an additive effect, if you wish.

As a result of getting the combined response of the two, if there is a synergistic effect, you will have it as a significant interaction. Can you answer that differently?

Question: I wanted to ask one related to it. I can't answer it. I don't have difficulty following what you have said. The mental block that I have is to picture a material with a hundred peaks. We don't need a hundred.

For example, with 26 letters in the alphabet, we can run into hundreds of thousands of words and these things don't have to follow vowels and consonents and so on. So that you can run into millions of combinations, and that is my mental block.

How does your taste panel overcome this enormous job of screening these combinations?

A. Kramer: The large number of combinations are among the peaks, and the computer does that. We don't ask the panel to pick out an infinite number of flavor notes. We don't ask them to do a flavor profile. We ask them to simply give us a flavor preference evaluation.

Questioner: But you give them components that represent the peak or the peak that represents the component. So you are confronted with 20 or 50 peaks that you wish to give in various combinations. And if you do this, you get again into the millions of combinations.

A. Kramer: That is the dilemma of the chemist which I am trying to solve statistically with a computer. Also, I am doing this in reverse by starting out with food products as such.

Now what you are asking perhaps is what would the flavor chemist do if he were going to take this bean product I am talking about and start adding components to it and then give that to the taste panel.

That would be another problem which I haven't considered. What I am suggesting here is an attempt to find a means of measuring the flavor quality of foods that are already complete foods, rather than determining the effect of any additives that may be added.

S. J. Hiemstra: I am the person responsible for computing the percentage of income spent for food. I'd like to go back to that one just briefly, if I may.

It seems to me there are two points being overlooked. First of all, food expenditures have been increasing in dollar amounts. Last year, food expenditures went up about five percent. They have been going up rather substantially each year. It is only because food expenditures don't go up as much as income that we have a decline in the proportion of income spent for food. Since total food expenditures have increased, returns to food processors have increased. Further, a lot of the decline in the proportion of income spent for food has been the result of decreased returns to farmers. Gross returns to food processors and marketing agencies in the past have increased at about the same rate as after tax income, and this situation likely will continue.

Secondly, the Marketing Economics Division of ERS, as well as other people, have conducted studies of costs of convenience foods, and they have found that in many cases costs of convenience foods are less than comparable nonconvenience foods--instant coffee and concentrated orange juice, for example. On the average, they have found that convenience foods cost no more than their counterparts. As a result, I think it is possible to have an increase in convenience foods even without having a further increase in total food expenditures. However, I do think expenditures for foods will continue to increase, and the increase in expenditures for processed foods will be even greater.

H. H. Mottern: Obviously you can have a complex food, say mincemeat, where the housewife has to shop for a number of items

and doesn't always buy them in the quantity that she will use them. She can buy the required amount and have mincemeat with no waste.

When it comes to concentrated orange juice, with the savings in freight, storage and so forth, there is a cost advantage. But this is not true when it comes to such things as instant sugar where all you need to do is just drop a spoonful in ice tea and it dissolves as it descends, or even instant flour which may be useful to spoon, and make a sauce, but certainly would cost more in baking bread.

How far can we go in that direction? It is not just a case of statistical projection but a case of not underestimating the power of a woman.

Question: I am still not clear on the dollar thing. Ignoring the population increase, here is my question, the question is, will the food processing industry receive more or less dollars from the population in the future? Can somebody answer that question?

H. G. Hamilton: I would say, ignore the population growth, this puts it on a per capita basis, I think the food processor and all the people that have to do with food are going to receive less per unit of service than they receive today, that is, the producer, the transportation company, the manufacturer, the distributor, and everybody. This will take place because of advancement in technology.

Question: Well then, my question is to this. Dr. Hiemstra just said that the food expenditure per capita was increasing by five percent, but that the increase in the expenditure was not keeping up with the increase in income.

So I still see a dilemma here.

H. G. Hamilton: It seems to me like this is quite consistent. It is simply saying that the income is increasing even faster than what the expenditure for food is.

S. J. Hiemstra: I don't know if I can add anything to this confusion or not. However, past trends have shown that there's been an increase in the amount of money going to processors. I don't think there's any question about this. On a per capita basis, you still get an increase in the amount of dollars going to processors. Apparently, I am not in agreement with Dr. Hamilton on this point.

H. G. Hamilton: Probably one of our disagreements is that you are saying that you are talking about the processor, he is performing more and more services all the time.

S. J. Hiemstra: I am not disputing that at all.

H. G. Hamilton: Well, for the same service, your food processor is going to get less income, I think. As processors increase their efficiency the cost to the consumer for a given service will be reduced and the income for performing a given service will be decreased to the processor.

S. J. Hiemstra: No, proportionately less of total income, but more in number of total dollars.

Question: Some discussion was had this morning about flavor potentiators and about synergistic effects. Has any work been done on flavor depreciators in the event you have an objectionable flavor?

I am thinking of one. I can't say that my wife cooks fresh turnips, but when my mother and my grandmother cooked fresh turnips, they always added a bunch of potatoes. They seemed to help the flavor because I think a lot of us objected to the strong flavor of the turnips.

Now, is that some field of flavor investigation that may need some attention?

E. Theimer: I think that last statement hit it right on the nose. It needs a lot of investigation. I think there are some indications that there are neutralization effects but they have not been well documented, and I certainly couldn't give you any references.

If you asked about the question of potentiators, I could refer you to a symposium that was held recently with some very careful scientific tables set up for the effect of one compound on another and what happens when you use varying amounts and under varying conditions.

But I don't know of any further work that's been done, although there is a potential

there. That these effects are possible at least, that is all I can say.

Question: This may be the wrong group to ask the question. I'd like to know if anybody can foresee any tendency for the farmer to stop being the goat and get a little bit bigger percentage of the dollar for what he produces?

A. Kramer: As a matter of fact, I was going to ask this question of Dr. Hamilton in somewhat a different way, and I have a specific example. I had mentioned in my earlier remarks that quality control as a system is being used and used more and more in the processing industry, but very little in the production of agricultural commodities or in the manufacture of the finished product for consumption.

And now my example is again with green beans. There is a variety called Black Valentine with which some of you may be familiar, and perhaps a lot of it comes from this area. It is very popular on the fresh market because it is easy to handle and it looks beautiful, the appearance is terrific.

The fiber content is astronomical. Why anybody after he brings it home wants to eat it, I really don't know.

Now, the reason for this, I am satisfied, is the fact that there is no adequate quality control in the production of these beans in relation to ultimate consumer or customer preference. As a result of this lack of quality control on the fresh market product, who eats fresh beans any more? They use canned or frozen beans.

They are processed, and so there is the added value and the added cost of the manufacturing process. However, if the growers were to put out a bean that not only looks nice when it is purchased in the fresh state but also tastes okay, and the texture is all right, why there would be a much better chance to hold onto this fresh market, and some of the farmers get a bigger share of the dollar for those beans. I grant that is only a partial answer.

J. C. Miller: I would like to talk about this. This old Black Valentine was the reason why it is still grown. Anyone who knows beans at all recommends the Black Valentine to the public, but when you have a bunch of shippers who demand that bean, why? We lay the beans out on the table and let them stay there for a week, and the rest of them will wilt.

The store manager wants a product that will look like a bean. And they insist they want the Black Valentine bean.

Now, going back to your flavors, we'd like to have a bean like Kentucky Wonder or the Blue Lake or something like that. But we have other good beans like Contender and many more.

But to sell the other bean varieties and get the shippers to try them is another proposition. We have to educate the shippers, organizations who control the growers.

The growers don't want it because it is a low-yielding bean. We have others that yield twice as much. But the shippers still demand it, they want the Valentine bean because it holds up quite a while.

E. Theimer: I wonder if I could comment on this general area just a moment from the long-range point of view, that the problem of developing a food product which is good from every standpoint seems to be just a little bit too tough to consider.

If you grow larger and larger strawberries, you get less and less flavor per strawberry, or possibly you get the same amount of flavor per strawberry, but you certainly get less flavor per unit weight.

If you change the size for the better, then you are going to change some other characteristics also, and for the worse. So I will come back to the proposal that we try to develop the finest food from the standpoint of quality, of texture, nutrition and so on, and then strip out all of the flavor if it is objectionable.

In other words, forget about the flavor, just get rid of it and add back synthetic flavors that we really know we want. This is not really so far-fetched. When you make a protein flour from fish and it is not properly processed, it has too much fishy quality and people don't want it. If it is too well processed, it is completely bland and people again don't want it.

What they want is just the amount that they by their past experience associate with

good fish, good fresh fish. Well, again, instead of trying to achieve this by controlled processing, rather let's get all these wonderful things all together into one final package by getting rid of all the flavor and then putting back the amount desired.

And this is something that we are actually working on. I think in the near future that this is certainly a possibility.

Question: This is for Mr. McCaffery. I was wondering if he could give us a little more information on the market test, telling us whether they are homogenized bananas, sliced, or for future problems?

T. J. McCaffery: The banana slices are slices that have been included in a package of corn flakes. We are drying the banana slices. We are not producing the product itself. Until we actually saw one of the packages of the finished product, we really had very little idea of exactly what was in this formulated banana product. It is very cleverly formulated. I don't know exactly how it is made, but I have a fairly good idea. I believe it consists of pureed or mashed banana mixed with cellulose gum, wheat starch and EDTA to preserve the color. As far as I know, that is the extent of the ingredients in the product.

The EDTA has apparently been added to preserve the pale yellow color typical of the banana. We have dried pure banana slices. As a matter of fact, some of you who have been in my office have seen a small jar of them that has been there for over two years. They are still just as nicely pale yellow as they were the day they were dried.

Why go to a formulated banana? Well, we have all eaten tart strawberries; I think we have all eaten fresh sweet ones. How would you achieve complete uniformity in a product unless you actually did homogenize and produce a formulated finished product?

I'm sure Dr. Theimer is very well acquainted with this sort of problem. We try to end up with a product that tastes the same all the time. When you begin with ingredients that vary from day to day, where you have different varieties of bananas and different degrees of ripeness, I feel that this is a very appropriate way to achieve a uniform product with something such as these banana slices.

V. H. McFarlane: Unless there are additional questions at this time, I wish to express my thanks to the members of the panel for their statements and for their willingness to answer the questions that have been raised.

I want also to express my thanks to everyone here for their attendance and interest in the program. I turn the microphone over to Dr. MacDowell for any closing announcements he may wish to make.

L. G. MacDowell: Thank you Dr. McFarlane, for presiding here this morning. I'd like to thank all of you for your attendance and close attention here this morning.

I think it would be appropriate at this time to extend our thanks, and with your permission I will do so, to the U. S. Department of Agriculture and its collaborators who have put together this instructive and informative conference.

I would particularly like to mention the Program Committee consisting of Dr. Wojcik as chairman, Dr. McFarlane, Mr. Vix, Dr. Mikell, Dr. Deobald, Mr. Spadaro, and Mr. Mazzeno. I think we owe them a vote of thanks.

Lastly, but not leastly, we thank Mrs. Sharar, our Girl Friday, who has really been the work horse.

Our even more unobtrusive helpmate, the fruits of her efforts which will come out at a little later time, is our recorder, Mrs. Ellis.

That concludes my remarks. I turn this meeting back to Dr. Wojcik for any further thoughts he may have. Thank you.

B. H. Wojcik: Thank you, Dr. MacDowell. Somebody asked a question about the storageability of sweet potatoes. In a private conference with Dr. Julian Miller, he informed me that you cannot store sweet potatoes in an atmosphere of CO_2 with complete satisfaction. According to Dr. Miller, it is essential that even under refrigeration air be gradually passed over the sweet potatoes for the best results.

Normally at this time our director, Dr. C. H. Fisher, makes appropriate closing remarks. He asked that I express to you his regrets for not being able to do so today.

Last-minute assignments from Washington and unexpected visitors who came to his office require that he stay at the laboratory.

On behalf of the Division and its staff, I wish to express appreciation to the State Experiment Station Directors, their Assistant Directors and collaborators, industry colleagues and others for participating in our program. We hope you have found this meeting informative, enjoyable, and that you will come back to see us again soon.

To all of you who have had an active part in the program, we are most grateful; to the chairman, Dr. O. B. Garrison, to the co-chairman, to Dr. MacDowell who led the panel discussion, to Dr. Kermit Bird who helped immeasurably in seeing that we would have a good attendance, and to Dr. McFarlane who really worked hard behind the scenes to make this conference so successful.

We also would like to thank Mr. M. H. Walker, the projectionist for his contribution to the program.

I remind you again that the proceedings will be mailed to you as soon as they become available.

Also I'd like to thank those who have supplied the samples, the little exhibit that we have in the back. Those of you who haven't taken a look at it yet please do so now.

This concludes our program. Once again thank you very kindly for your participation and cooperation and your attendance.

ATTENDANCE LIST

Amundson, Clyde H., Dept. Dairy and Food Inds, Univ. Wisconsin, Babcock Hall, Madison, Wis. 53706

Anthony, Raymond C., Southeastern Louisiana College, Route 1, Box 20-C, Tickfaw, La. 70466

Bailey, Galen, United Foods, Inc., Hammond, La. 70401

Baird, Guy B., Agr. Expt. Sta., Univ. North Carolina, Raleigh, N. C. 27607

Barnhart, Charles E., Agr. Expt. Sta., Univ. Kentucky, Lexington, Ky. 40506

Barrios, Earl, Hort. Dept., Louisiana State Univ., P.O. Box 8877, Univ. Sta., Baton Rouge, La. 70803

Barry, Helen C., FDA, Room 222, Customs House, 423 Canal St., New Orleans, La. 70130

Bash, W.D., Ohio State Univ., 1827 Neil Ave., Columbus, Ohio 43010

Baumgardner, Reginald A., Hort. and Landscape Architecture, Louisiana State Univ., P.O. Box 8877, Univ. Sta., Baton Rouge, La. 70803

Becker, Charles A., Development Department, Org. Chem. Div., Monsanto Chem. Co., 800 N. Lindbergh Blvd., St. Louis, Mo. 63166

Bigner, George W., Louisiana State Univ., 342 South 21st St., Baton Rouge, La. 70806

Bird, Kermit, Market. Econ. Div., ERS, USDA, Washington, D. C. 20250

Blake, Melvyn, Continental Can Co., 1200 West 76th St., Chicago, Ill. 60620

Blanchett, Roland, Green Giant, Le Sueur, Minn. 56058

Blomquist, V. H., Food Tech. Branch, FDA, Washington, D. C. 20250

Bologna, Anthony F., R. J. Reynolds Tobacco Co., Winston Salem, N. C. 27102

Bone, D., Quaker Oats Co., 617 West Main St., Barrington, Ill. 60010

Boudreaux, E. C., New Orleans District, FDA, 222 Custom House, 423 Canal St., New Orleans, La. 70130

Bowles, James, Southeastern Louisiana College, Hammond, La. 70401

Brady, Nyle C., Director of Science and Education, USDA, Washington, D. C. 20250

Brew, William, Cen. Res. and Control Labs., Ralston-Purina Co., 835 S. Eighth St., St. Louis, Mo. 63199

Brittin, W. A., Prod. Dev., Stange Co., 342 North Western Ave., Chicago, Ill. 60612

Broce, Domiciano, Louisiana State Univ., 1473 Duane St., Baton Rouge, La. 70802

Brown, Jack, Blaw-Knox Co., East Chicago, Ind. 46312

Browne, E. Broadus, Agr. Expt. Sta., Univ. Georgia, Athens, Ga. 30601

Brunet, Orestes E., Jr., Louisiana State Univ., P.O. Box 21136, New Orleans, La.

Bryant, Elizabeth C., Southeastern Louisiana College, P.O. Box 1299, Hammond, La. 70402

Bryant, Ernest W., Louisiana State Univ., 705 W. Thomas St., Hammond, La. 70401

Buchanan, Ben, General Foods Corp., Tech. Cen., Corporate Res. Dept., 250 North St., White Plains, N.Y. 10591

Burk, Earl F., Food Inspection, AMS, Fruit and Veg., USDA, P.O. Box 159, Hammond, La. 70401

Burr, H.K., Veg. Lab., West. Util. Res. and Devlpmt. Div., 800 Buchanan St., Albany, Calif. 94710

Byerly, T.C., Coop. State Res. Serv., Agricultural Research, USDA, Room 313, Building A, Washington, D.C. 20250

Calvert, F.E., Soybean Res., Ralston-Purina Co., 835 S. Eighth St., St. Louis, Mo. 63199

Camatsos, Victor, Louisiana State Univ., 256 W. Roosevelt St., Baton Rouge, La. 70802

Campbell, John A., Truck Crops Expt. Sta., Crystal Springs, Miss. 39059

Cancel, Luis, Univ. Puerto Rico, Agr. Expt. Sta., Rio Piedras, P.R. 00927

Chambers, Doyle, Agr. Expt. Sta., Louisiana State Univ., P.O. Box 8877, Univ. Sta., Baton Rouge, La. 70803

Champion, Robert M., Louisiana State Univ., 5997 Evangeline St., Baton Rouge, La. 70805

Cording, James, Jr., Eng. and Dev. Lab., East. Util. Res. and Devlpmt. Div., 600 Mermaid Lane, Philadelphia, Pa. 19118

Cralley, E.M., Agr. Expt. Sta., Univ. Ark., Fayetteville, Ark. 72701

Dack, Gail M., Food Res. Inst., Univ. Chicago, Chicago, Ill. 60637

Daly, John J., Jr., New Prods. and Mkt. Devlpmt., E.I. du Pont de Nemours & Co., Chestnut Run, Wilmington, Del. 19898

Daniels, Richard D., Gaunart Dev. & Trading Corp., 343 Washington Bldg., Washington, D.C. 20005

Danna, Emile J., Proc. Foods Insp., AMS, Fruit and Veg., USDA, Hammond, La. 70401

Decareau, Robert, Litton Inds., 974 Commercial St., Palo Alto, Calif. 94303

Dennery, Theodore, Charles Dennery, Inc., 698 St. George Ave., New Orleans, La. 70121

Dienst, Carl S., The Pillsbury Co., 311 Second St., S.E., Minneapolis, Minn. 55414

Dietz, Max R., Gerber Prods. Co., RRI, Fremont, Mich. 49412

Dupre, James R., FDA, 222 Custom House, 423 Canal St., New Orleans, La. 70130

Duren, J.T., Libby, McNeill & Libby, 1800 West 119th St., Chicago, Ill. 60643

Ebbert, S.A., United Foods Inc., Hammond, La. 70401

Essary, E.O., Poultry Prods., Virginia Polytechnic Inst., Blacksburg, Va. 24061

Ewing, John A., Agr. Expt. Sta., Univ. Tennessee, Knoxville, Tenn. 37900

Ezell, Ronald, Southeastern Louisiana College, 208 W. Coleman, Hammond, La. 70402

Farag, Mohamed K., Dept. of Food Sci. and Tech., Louisiana State Univ., P.O. Box 16694, Baton Rouge, La. 70803

Farris, Nolan F., Coop. State Res. Serv., USDA, Washington, D.C. 20250

Fuestel, I.C., FES, USDA, Albany, Calif.

Flick, George J., Louisiana State Univ., P.O. Box 19101, Baton Rouge, La. 70803

Fort, Charles A., Retired, 430 Florida Blvd., New Orleans, La. 70124

Fruge, Jack C., Fruge and Foret Law Office, Court St., Ville Platte, La. 70586

Fullilove, W.T., Agr. Expt. Sta., Univ. Georgia, Experiment, Ga. 30212

Gandy, Dalton E., Res. and Educ. Div., Nat. Cottonseed Prods. Assoc., Inc., P.O. Box 286, Technical Sta., Ruston, La. 71271

Ganz, A. Jerome, Hercules Powder Co., Hercules Res. Cen., Wilmington, Del. 19899

Garner, R.G., Util. Div., Coop. State Res. Serv., USDA, Washington, D.C. 20250

Garrison, O.B., Agr. Expt. Sta., Clemson Univ., Clemson, S.C. 29631

Gerrish, O.B., Midwest Res. Inst., 425 Volker, Kansas City, Mo. 64113

Goeser, Paul, Swift & Co., Chicago, Ill. 60604

Goldsmith, Grace A., School of Medicine, Tulane Univ., New Orleans, La. 70112

Gralow, Ray C., Corn Products Co., 717 Fifth Ave., New York, N.Y. 10022

Gretler, A.C., Mead Johnson & Co., Evansville, Ind. 47721

Griffin, E.L., Eng. and Dev. Lab., North. Util. Res. and Devlpmt. Div., 1815 North University St., Peoria, Ill. 61604

Grodner, Robert M., Dept. of Food Sci. and Tech., Louisiana State Univ., P.O. Box 8877, Univ. Sta., Baton Rouge, La. 70803

Hallab, A.H., Louisiana State Univ., Food Sci. Dept., Baton Rouge, La. 70803

Hamilton, H.G., Dept. of Agr. Econ., Agr. Expt. Sta., Univ. Florida, 162 B McCarty Hall, Gainesville, Fla. 32603

Harris, Hubert, Agr. Expt. Sta., Auburn Univ., Auburn, Ala. 36830

Hawbecker, J.V., Pet Milk Co., Bigler-ville, Pa. 17307

Hawkins, L.E., Agr. Expt. Sta., Oklahoma State Univ., Stillwater, Okla. 74075

Haymon, L. Wendell, Louisiana State Univ., P.O. Box X, Baton Rouge, La. 70803

Hebert, William O., FDA, 222 Custom House, 423 Canal St., New Orleans, La. 70130

Henry, Wayne E., Carnation Co., 8015 Van Nuys Blvd., Van Nuys, Calif. 91402

Hernandez, Teme P., Louisiana State Univ., P.O. Box 8877, Univ. Sta., Baton Rouge, La. 70803

Hiemstra, Stephen J., Food Consumption Sect., ERS, USDA, Washington, D.C. 20250

Hill, Elmer C., Citrus Expt. Sta., State of Florida, Lake Alfred, Fla. 33802

Howell, Dorothy C., Foods and Nutrition, Louisiana State Univ., 874 Delgado, Baton Rouge, La. 70808

Hunter, John E., Procter & Gamble, 6000 Center Hill Rd., Cincinnati, Ohio 45224

Jaffan, Raja, Louisiana State Univ., P.O. Box 18272, Baton Rouge, La. 70803

Jamison, F.S., Veg. Crops. Dept., Univ. Florida, Gainesville, Fla. 32603

Jimes, Selvestion, Louisiana State Univ., 819 Wiltz Dr., Baton Rouge, La. 70806

Johnson, Christian M., West Jefferson General Hospital, 4500 Eleventh St., Marrero, La. 70072

Johnston, Melvin R., Food Technical Dept., Agr. Expt. Sta., Univ.

Tennessee, P. O. Box 1071, Knoxville, Tenn. 37900

Jorgensen, Donald J., Mkt. Exploration Dev. Dept., Org. Chem. Div., Monsanto Chem. Co., 800 N. Lindbergh Blvd., St. Louis, Mo. 63166

Kelly, R. F., Virginia Polytechnic Inst., Dept. of Animal Sci., Blacksburg, Va. 24061

Kloehn, Joan M., Dept. of Food Sci., Stanford Res. Inst., Menlo Park, Calif. 94025

Kohl, W. F., Food Res. Labs., Stauffer Chem. Co., Chicago Heights, Ill. 60413

Kramer, Amihud, Agr. Expt. Sta., Univ. Maryland, College Park, Md. 20742

Kuboviak, M. L., United Foods Inc., Hammond, La. 70401

Kuhn, Gerald D., Agr. Expt. Sta., Univ. Florida, Gainesville, Fla. 32603

Kunkel, H. O., Agr. Expt. Sta., Texas A&M Univ., College Station, Texas 77843

Ladner, Cornell M., Southeastern Louisiana College, Hammond, La. 70402

Langdon, Earl E., Customer Res., Continental Can Co., 1310 Richards Bldg., New Orleans, La. 70112

Lanham, Ben T., Jr., Agr. Expt. Sta., School of Agriculture, Auburn Univ., Auburn, Ala. 36830

Le Blanc, Daniel, Southeastern Louisiana College, P. O. Box 478, Hammond, La. 70402

Lee, Elmo, Dept. of Food Sci., Louisiana State Univ., P. O. Box 8877, Univ. Sta., Baton Rouge, La. 70803

Leveck, Henry H., Agr. Expt. Sta., Mississippi State Univ., State College, Miss. 39762

Lewis, Harvey L., Res. and Dev., Henningsen Foods, Inc., 2501 College St., Springfield, Mo. 65802

Liuzzo, Joseph A., Dept. of Food Sci. and Tech., Louisiana State Univ., Box 8877, Univ. Sta., Baton Rouge, La. 70803

Love, Travis, U. S. Fish and Wildlife, Pascagoula, Miss. 39567

Lovell, Richard T., Dept. of Food Sci., Louisiana State Univ., P. O. Box 8877, Univ. Sta., Baton Rouge, La. 70803

Lovvorn, R. L., Agr. Expt. Sta., Univ. of North Carolina, State College Sta., Raleigh, N. C. 37607

Lugo-López, M. A., Agr. Expt. Sta., Univ. of Puerto Rico, Rio Piedras, P. R. 00927

Lutz, Jacob M., Mkt. Qual. Res. Div., ARS, USDA, Hyattsville, Md. 20781

MacDowell, L. G., Florida Citrus Comm. State of Florida, Lakeland, Fla. 33802

Marston, H. W., For. Res. and Tech. Programs Div., ARS, USDA, Washington, D. C. 20250

Martin, Dudley C., Dept. of Hort., Univ. of Kentucky, Lexington, Ky. 40506

Martin, R. D., Westreco Inc., Marysville, Ohio 43040

Martin, William McKinley, Consultant, 457 Virginia Ave., San Mateo, Calif. 94402

McCaffery, T. J., United Fruit and Food Corp., P. O. Box 187, Edinburg, Tex. 78539

McPherson, A. T., 4005 Cleveland St., Kensington, Md. 20795

McPherson, Margaret W., Retired, George Washington Univ., 4005 Cleveland, Kensington, Md. 20795

Mikell, John J., Agr. Expt. Sta., Louisiana State Univ., P. O. Box 8877, Univ. Sta., Baton Rouge, La. 70803

Miller, Julian C., Dept. of Hort. and Landscape Architecture, Louisiana State Univ., P. O. Box 8877, Univ. Sta., Baton Rouge, La. 70803

Milner, Max, Food Conservation Div., UNICEF, United Nations, N. Y. 10017

Mitchell, Wendell, Southeastern Louisiana College, P. O. Box 362, Hammond, La. 70402

Morgan, A. I., Jr., Eng. and Dev. Lab., West. Util. Res. and Devlpmt. Div., 800 Buchanan St., Albany, Calif. 94710

Morris, Justin R., Processing Crops, Univ. Arkansas, 221 Gray Hall, Fayetteville, Ark. 72701

Morrow, Albert P., Tenco Div., Coca-Cola Co., P. O. Box 15, Linden, N. J. 07036

Morton, Lee, Dr. Pepper Co., P. O. Box 5086, Dallas, Tex. 75222

Moshy, Raymond J., Res. and Devlpmt. Div., Chem. Dev. Labs., American Machine and Foundry Co., 689 Hope St., Springdale, Conn. 06879

Mottern, H. H., 844 Central St., Glenview, Ill.

Nelson, G. G., Res. Dept., General Foods Ltd., Cobourg, Ontario, Canada

Nelson, H. G., Mrs., Home Economics, Southeastern Louisiana College, Hammond, La. 70402

Nelson, H. G., Food Technology, Southeastern Louisiana College, Hammond, La. 70402

Newsom, Donald W., Hort. and Landscape Architecture, Louisiana State Univ., P. O. Box 8877, Univ. Sta., Baton Rouge, La. 70803

Novak, Arthur F., Department of Food Sci. and Tech., Louisiana State Univ., 1241 W. Chimes St., Baton Rouge, La. 70802

Nur, M. Anwar, Louisiana State Univ., 149 E. State, Baton Rouge, La. 70802

O'Connell, Jack J., Silveira & O'Connel, P. O. Box 320, Sebastopol, Calif. 95472

O'Connell, Jim, Jas. E. O'Connell Company, Inc., P. O. Box 149, Sebastopol, Calif. 95472

Odell, A. D., Isolated Protein Program, General Mills, Inc., 9000 Plymouth Ave., North, Minneapolis, Minn. 55427

Olsen, Robert W., Citrus Expt. Sta., Lake Alfred, Fla. 33850

Parker, W. E., Miss. Fed. Coop., Crystal Springs, Miss. 39059

Pearl, Robert C., Agr. Ext. Serv., Univ. California, 109 Cruess Hall, Davis, Calif. 95616

Pendergrass, Robert P., FDA, 222 Customs House, 423 Canal St., New Orleans, La. 70130

Potter, Norman, Food Tech., Res. and Devlpmt. Div., Chem. Dev. Labs., American Machine and Foundry Co., 689 Hope St., Springdale, Conn. 06879

Pyburn, Helen M., Dept. of Home Economics, Southeastern Louisiana College, Hammond, La. 70402

Reaves, William J., R. J. Reynolds Tobacco Co., Winston-Salem, N. C. 27102

Reynolds, James M., The Nestlé Co., 100 Bloomingdale Rd., White Plains, N. Y. 10605

Roberts, W. M., Dept. of Food Sci., Agr. Expt. Sta., Univ. North Carolina, Raleigh, N. C. 27607

Robideau, Mary, Cen. Res. Lab., General Mills, Inc., James Bell Res. Cen., 9000 Plymouth Ave. North, Minneapolis, Minn. 55427

Robinson, Arthur L., Robinson Extract Co., Inc., 5837 Berkley Dr., New Orleans, La. 70114

Rogers, A. Barde, Food Res. Div., Armour and Co., 801 West 22nd St., Oak Brook, Ill. 60523

Schember, V. E., Agr. Expt. Sta., Texas A&M Univ., College Sta., Tex. 77843

Schlosser, Georgia, ARS, USDA, Washington, D. C. 20250

Schuldt, Erich H., Anheuser-Busch, 721 Pestalozzi St., St. Louis, Mo. 73118

Seay, W. A., College of Hort. Economics, Univ. Kentucky, Lexington, Ky. 40506

Seltzer, Edward, Thomas J. Lipton, Inc., 800 Sylvan Ave., Englewood Cliffs, N. J. 07632

Senti, F. R., ARS, USDA, Washington, D. C. 20250

Sites, John W., Agr. Expt. Sta., Univ. Florida, Gainesville, Fla. 32603

Smith, Allan K., Consultant, 4671 Painters St., New Orleans, La. 70122

Smith, Claude, Food Div., Miss. Fed. Coop., 414 North St., Jackson, Miss. 39202

Smith, E. V., Agr. Expt. Sta., Auburn Univ., Auburn, Ala. 36830

Smith, John C., Prod. Res., Uncle Ben's, Inc., P. O. Box 1752, Houston, Tex. 77001

Smith, Kent, FDA, 222 Custom House, 423 Canal St., New Orleans, La. 70130

Steinberg, Marvin P., Dept. of Food Sci., College of Agriculture, Univ. Illinois, Urbana, Ill. 61803

Stephens, Charles R., Chas. Pfizer and Co., Inc., Groton, Conn. 06340

Sylvester, Oscar, Jr., c/o Fruge and Foret Law Office, Court St., Ville Platte, La. 70586

Takagi, Akira, Produce Dept., Mitsui V. Co., 200 Park Ave., New York, N. Y. 10017

Tamsma, A., Dairy Prods. Lab., East. Util. Res. and Devlpmt. Div., USDA, South Bldg., Room 0622, Washington, D. C. 20250

Theimer, Ernst, Res. and Devlpmt., Internat. Flavors and Fragrances, Inc., 800 Rose Lane, Union Beach, N. J. 07735

Thornton, N. C., United Fruit and Food Corp., 80 Federal St., Boston, Mass. 02110

Thrash, Nelle, Ext. Food Preservation Dept., Univ. Georgia, Hoke Smith Annex, Athens, Ga. 30601

Thulin, Walter W., Mkt. Res. and Devlpmt., Cen. Res. Labs., General Mills, Inc., James Ford Bell Res. Cen., 9000 Plymouth Ave. North, Minneapolis, Minn. 55427

Torrie, K. M., Res. Dept., General Foods, Ltd., Cobourg, Ontario, Canada

Truitt, W. C., Corbett Assoc., Inc., Ville Platte, La. 70586

Upchurch, Melvin L., Farm Prods. Econ. Div., ERS, USDA, Room 4909, Bldg. S, Washington, D. C. 20250

Vanderzant, C., Dept. of Dairy Sci., Texas A&M Univ., College Sta., Tex. 77843

Vidrine, Clyde, Evangeline Oil Mill, 131 Court St., Ville Platte, La. 70586

Waitman, Reuben, Jello Res. Lab., General Foods Corp., White Plains, N. Y. 10591

Walker, Paul N., Brown Miller Co., Pickle Packers Internat., P. O. Box 10278, New Orleans, La. 70121

Waters, Melvin E., U. S. Fish and Wildlife Service, P. O. Box 1207, Pascagoula, Miss. 39567

Westbrooks, James H., Sales Dept., Continental Can Co., 1310 Richards Bldg., New Orleans, La. 70112

Wharton, F. D., Jr., Monsanto Chem. Co., 800 N. Lindbergh St., St. Louis, Mo. 63166

Whatley, J. A., Okla. Agr. Expt. Sta., Stillwater, Okla. 74075

Wilkowske, H. H., Agr. Expt. Sta., Univ. Florida, Gainesville, Fla. 32603

Williams, Donald H., Dairy & Food Inds. Supply Assoc., 1145 - 19th St., N. W., Washington, D. C. 20036

Williams, W. P., Jr., Dept. of Food Sci. and Biochemistry, Clemson Univ., Clemson, S. C. 29631

Williamson, J. C., Jr., School of Agriculture, Univ. North Carolina, Agr. Expt. Sta., Raleigh, N. C. 27607

Wilson, Coyt T., Agr. Expt. Sta., Virginia Polytechnic Inst., Blacksburg, Va. 24061

Wingenbach, James J., F.J. Stokes Co., 5500 Tabor Rd., Philadelphia, Pa. 19120

Wodicka, Virgil O., Hunt-Wesson Foods, 1645 West Valencia Dr., Fullerton, Calif. 92633

Wood, Charles B., Food Tech., Agr. Expt. Sta., Virginia Polytechnic Inst., Blacksburg, Va. 24061

Woodroof, J. G., Food Sci. Div., Agr. Expt. Sta., Univ. Georgia, Experiment, Ga. 30212

Wright, Salmon L., III, Wright Lab., P. O. Box 215, Crowley, La. 70526

Yang, S. P., Louisiana State Univ., P. O. Box 8877, Univ. Sta., Baton Rouge, La. 70803

Yeatman, John N., ARS, USDA, Room 6B, Admin. Bldg., Plant Ind. Sta., Beltsville, Md. 20705

Personnel in Attendance

from

SOUTHERN UTILIZATION RESEARCH AND DEVELOPMENT DIVISION

Altschul, Aaron M. (Dr.) - Seed Protein Pioneering Res. Lab.

Berquist, Jack J., - Administrative and Plant Management
Bourdette, Vernon R. - Information Office

Carpenter, Frank G. (Dr.) - Food Crops Lab.
Catalano, Edwin A. - Food Crops Lab.
Clasen, Glenn P. - Administrative and Plant Management
Codifer, Louis P., Jr., - Oilseed Crops Lab.
Cucullu, Alva F. (Mrs.) - Oilseed Crops Lab.

Deobald, Harold J. (Dr.) - Food Crops Lab.
Dollear, Frank G. - Oilseed Crops Lab.
Dupuy, Harold P. (Dr.) - Oilseed Crops Lab.

Etchells, John L. (Dr.) - Food Fermentation Lab., Univ. North Carolina, Raleigh, N. C.

Feuge, Reuben O. - Oilseed Crops Lab.
Fisher, Charles H. (Dr.) - Director's Office
Frampton, Vernon L. (Dr.) - Oilseed Crops Lab.

Gallo, Alexander S. - Eng. and Devlpmt. Lab.
Gastrock, Edward A. - Eng. and Devlpmt. Lab.
Goldblatt, Leo A. (Dr.) - Oilseed Crops Lab.
Griffiths, F. P. - Fruit and Veg. Prods. Lab., Weslaco, Tex.

Hasling, Vera C. - Food Crops Lab.
Hausser, Mary C. (Mrs.) - Director's Office
Hester, Opie C. - Economic Research Service
Hilding, Loeta B. (Mrs.) - Information Office
Hoffpauir, Carroll L. - Director's Office

Ikemiya, Masayuki (Dr.) - Food Crops Lab.

Jones, Marie A. - Information Office
Jones, Mary Alice B. (Mrs.) - Director's Office

Lambou, Madeline G. (Mrs.) - Eng. and Devlpmt. Lab.
Lee, Louise S. (Mrs.) - Oilseed Crops Lab.

Martinez, Wilda H. (Mrs.) - Oilseed Crops Lab.
Massaro, Emma L. (Mrs.) - Administrative and Plant Management
Mayne, Ruth Y. - Oilseed Crops Lab.
Mazzeno, Laurence W., Jr. - Director's Office
McFarlane, Vernon H. (Dr.) - Food Crops Lab.
McLemore, Taylor A. - Food Crops Lab.

Nelson, Mary L. (Dr.) - Plant Fibers Pioneering Res. Lab.

O'Connor, Robert - Cotton Phys. Props. Lab.

Pearce, Ellen S. (Mrs.) - Director's Office
Pearce, Henry M., Jr. - Eng. and Devlpmt. Lab.

Pominski, Joseph - Eng. and Devlpmt. Lab.

Scott, W. Clifford - Fruit and Veg. Prods. Lab., Winter Haven, Fla. 33882
Senn, Vincent J., Jr. (Dr.) - Oilseed Crops Lab.
Sharar, Beatrice A. (Mrs.) - Director's Office
Skau, Evald L. (Dr.) - Oilseed Crops Lab.
Spadaro, James J. - Eng. and Devlpmt. Lab.

Veldhuis, M. K. - Fruit and Veg. Prods. Lab., Winter Haven, Fla. 33882

Villacorta, Maria Luisa - Oilseed Crops Lab.
Vix, Henry L. E. - Eng. and Devlpmt. Lab.

Wadsworth, James I. - Eng. and Devlpmt. Lab.
Walker, Merlin H. - Plant Management
Williams, Nancy R. (Mrs.) - Economic Research Service
Wojcik, Bruno H. (Dr.) - Director's Office

Ziegler, George M., Jr. - Eng. and Devlpmt. Lab.

UNITED STATES DEPARTMENT OF AGRICULTURE
AGRICULTURAL RESEARCH SERVICE
SOUTHERN UTILIZATION RESEARCH & DEVELOPMENT DIVISION
P. O. BOX 19687
NEW ORLEANS, LOUISIANA 70119

OFFICIAL BUSINESS

POSTAGE AND FEES PAID
U. S. DEPARMTENT OF AGRICULTURE